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HANDBOOK
FIELD MAINTENANCE INSTRUCTIONS

RADIO TRANSMITTING SET

AN/URW-3A

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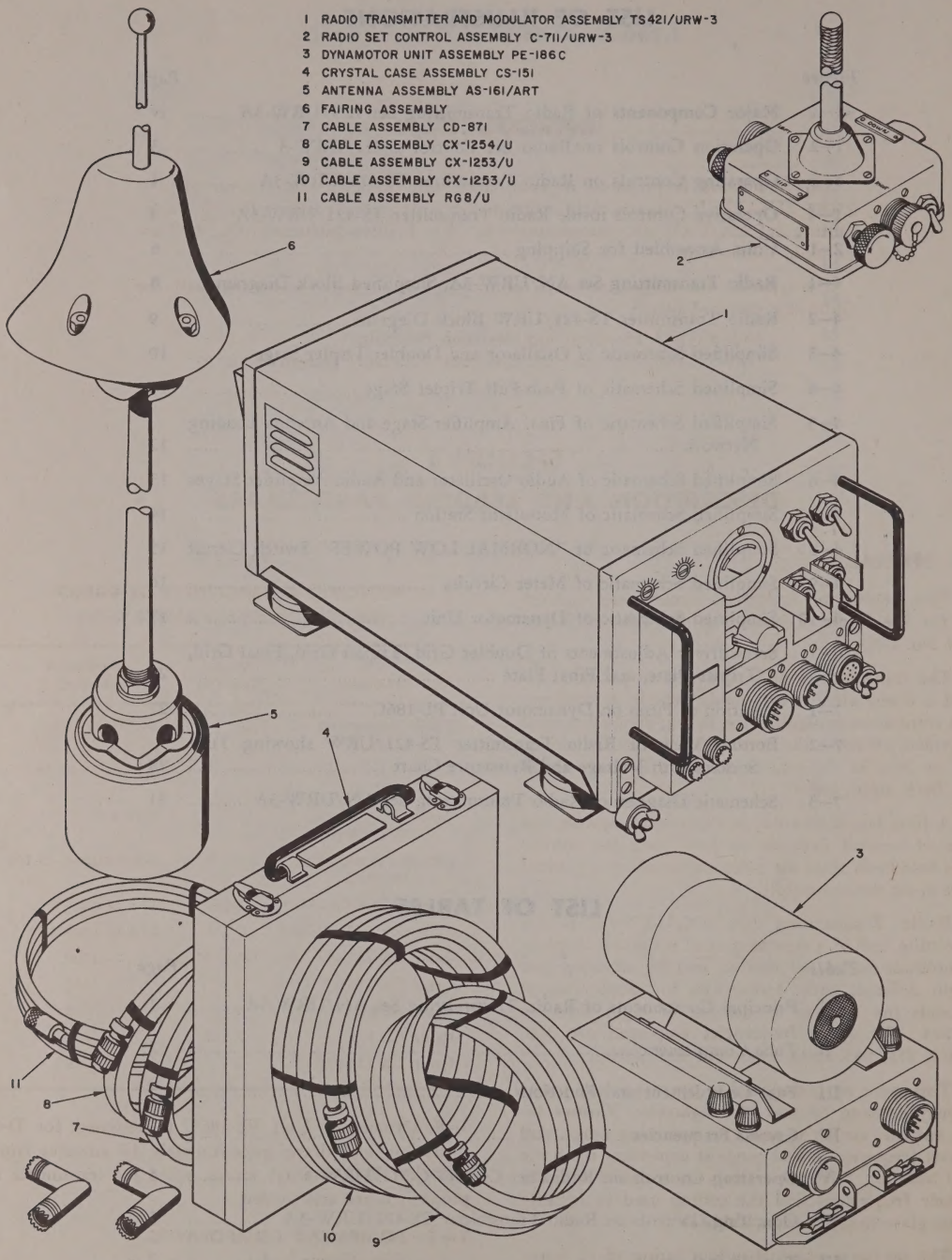
1 RADIO TRANSMITTER AND MODULATOR ASSEMBLY TS421/URW-3
2 RADIO SET CONTROL ASSEMBLY C-711/URW-3
3 DYNAMOTOR UNIT ASSEMBLY PE-186C
4 CRYSTAL CASE ASSEMBLY CS-151
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Figure 1—1. Major Components of Radio Transmitting Set AN/URW-3A

INTRODUCTION

This handbook is prepared in accordance with military specification MIL-H-25095 (USAF). It contains field maintenance instructions covering Radio Transmitting Set AN/URW-3A, manufactured by New London Instrument Co., of New London, Connecticut.

The symbols and designations used on drawings herein are in accordance with the following standard plans:

JAN-STD-15, Electrical and Electronic Symbols;
JAN-STD-16, Electrical and Electronic Reference Designations.

SECTION I
DESCRIPTION AND LEADING PARTICULARS

1—1. GENERAL.

1—2. This publication comprises maintenance instructions for the Radio Transmitting Set AN/URW-3A, Model No. 164.

1—3. The transmitting set is designed to provide control of a drone aircraft or ground vehicle. It does not give a continuous control of the drone; stepped control is provided, to move the controlled aircraft up, down, right, or left, as desired, or to move a land vehicle ahead, back, right, or left.

1—4. A time lag is inherent in this control system; the degree of control depends on how long the control stick is held back, since the radio system effects a gradual change in the drone controls.

1—5. Radio Transmitting Set AN/URW-3A is the transmitting end of a remote-control system. It employs an amplitude-modulated carrier, and by selecting one of eight different audio frequencies for modulation, it commands the receiver to do one of eight different functions. The audio frequencies employed are 300, 475, 650, 755, 955, 1390, 1900, and 3000 cycles.

1—6. This radio set is designed to operate at any preset frequency between 50 and 95 megacycles. Various internal switches are set to select an operating range, and the exact frequency in that range is dependent upon the crystal installed. Fifty-one crystals are supplied with the set; their frequencies and the coding used to identify each are given in this section, Table IV.

1—7. The set has a nominal output rating of 12 watts. It is rated to deliver a minimum of 10 watts with a 22-volt supply. This equipment cannot be allotted a specific distance range because of the effect of varying atmospheric, electrical, or topographic conditions.

TABLE I

PRINCIPAL COMPONENTS OF RADIO TRANSMITTING SET AN/URW-3A

Component	Weight (pounds)	Dimensions (inches)
Radio Transmitter TS-421/URW	34	24-3/4 x 11 x 9
Dynamotor Unit PE-186C	19	9-1/2 x 7 x 8-1/2
Radio Set Control C-711/URW-3	3	7 x 6 x 7-3/4
Antenna Equipment AS-161/ART	5-1/2	4-3/4 diam x 45-1/4
Crystal Case CS-151	8-1/2	12 x 12 x 2-1/2
Mounting MT-D1-B1	2	25 x 11-1/4 x 2
Cable CX-1253/U	21	1200
Cable CX-1253/U	5	120
Cable RG8/U	4	96
Cable CD-871	2-1/2	72
Cable CX-1254/U	1	48

1—8. Dynamotor Unit PE-186C is designed for D-C operation, and draws approximately 14 amperes from a 28-volt D-C external source, when the transmitter is properly tuned and loaded.

1—9. EQUIPMENT COMPONENTS.

(See Figure 1—1.)

1—10. The principal components of the transmitting set are: 1. Radio transmitter TS-421/URW; 2. dynamotor unit PE-186C; 3. radio set control C-711/URW-3;

4. antenna assembly AS-161/ART; and 5. crystal case CS-151. All of these units are shown in Figure 1—1; they are briefly described hereafter and are listed in Table 1.

1—11. RADIO TRANSMITTER TS-421/URW. (See 1, Figure 1—1.) The radio transmitter chassis and the front cover are rigidly joined together, and they slide into shock-mounted cabinet. Two screw fasteners on the rear of the cabinet hold the chassis in place. The cabinet in turn is held in place on Mounting (MT-B1-D1) by two wing fasteners on the front of the cabinet near the sides. Two handles on the front cover are used to pull the chassis from the cabinet. All operational controls, a tuning meter and five receptacles are mounted on the front cover. The modulator-transmitter unit contains the audio-frequency oscillator and amplifier circuits and the radio-frequency crystal and frequency-multiplying circuits, as well as operating controls.

1—12. DYNAMOTOR UNIT PE-186C. (See 3, Figure 1—1.) The dynamotor unit converts a 24- to 28-volt D-C input to 400 volts D-C output. The unit includes a filter for the 400-volt output. All power for the transmitting equipment passes through the dynamotor unit, which comprises the dynamotor, filter, two cable receptacles, high-voltage fuses, low-voltage fuses, holders with spare fuses, and a mounting. Mounting Plate FT-497 is a plate with four studs to engage the snap slide fasteners on the dynamotor units.

1—13. RADIO SET CONTROL C-711/URW-3. (See 2, Figure 1—1.) Radio set control C-711/URW-3 consists of a rectangular metal box upon which are mounted a control stick with positions marked "UP-DOWN-LEFT-RIGHT"; three switches marked "STUDENT-INSTRUCTOR", "PARACHUTE", and "CARRIER", respectively; two receptacles; a volume control; and a phone jack. The "UP" and "DOWN" position labels may be turned over, and will then read "REVERSE" and "FORWARD", respectively.

1—14. ANTENNA EQUIPMENT. (See 5, Figure 1—1.) Antenna assembly AS-161/ART consists of a vertical mast with the plug receptacle on the lower end. The whole assembly is slipped through Antenna Base AB-29/ART which is fastened to the skin of the airplane.

1—15. CRYSTAL CASE. (See 4, Figure 1—1.) Crystal case CS-151 is a painted metal case used for transportation and storage of the spare crystals for use with the Radio Transmitter Set; it also contains a screwdriver for tuning the transmitter. The case is felt-lined, with individual storage area for each crystal. The crystal case also contains crystal code cards for the transmitter and for the unit being controlled. The cards are marked with the code indicated in Table IV, indicating the frequency being used. The larger cards, to be mounted on the unit being controlled, measure five inches square, and are stacked in one corner of the crystal case. The smaller card, measuring 1-11/16 inches by 21/32 inch, are to be mounted on the transmitter. The case itself measures 11-5/8 x 12 x 2-1/4 inches.

1—16. TUBE COMPLEMENT.

1—17. The following table lists the tubes used in Radio Transmitting Set AN/URW-3A. All tubes are located in Radio Transmitter TS-421/URW.

1—18. FUSE COMPLEMENT.

1—19. The fuse complement and functions of Radio Transmitting Set (AN/URW-3A) are given in table III. The fuses are located in Dynamotor Unit PE-186C.

TABLE II

TUBE COMPLEMENT

Reference Number	JAN Type	Description	Function
V-210	JAN-5814A	Twin Triode	300-cycle and 955-cycle oscillator
V-211	JAN-5814A	Twin Triode	475-cycle and 1390-cycle oscillator
V-212	JAN-5814A	Twin Triode	650-cycle and 1900-cycle oscillator
V-213	JAN-5814A	Twin Triode	755-cycle and 3000-cycle oscillator
V-214	JAN-5814A	Twin Triode	Push-pull audio amplifier stage
V-217	JAN-6L6WGB	Pentode	1/2 of push-pull modulator
V-218	JAN-6L6WGB	Pentode	1/2 of push-pull modulator
V-301	JAN-815	Twin Pentode	RF oscillator and frequency multiplier
V-302	JAN-815	Twin Pentode	Push-pull tripler
V-303	JAN-815	Twin Pentode	Push-pull amplifier

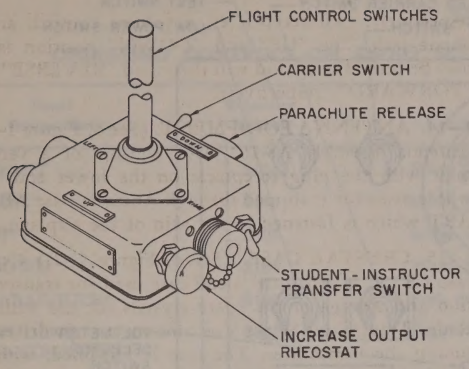


Figure 1—2. Operation Controls on Radio Set Control C-711/URW-3

TABLE III

FUSE COMPLEMENT AND FUNCTIONS

Reference Number	Type	Rating	Function
F-501	3AB	40A, volts	Low-voltage line protection
F-502	3AG	0.6A, volts	High-voltage line protection

1—20. FREQUENCY RANGES.

1—21. Radio Transmitting Set AN/URW-3A is designed for operation on a preset frequency within the range of 50 to 95 megacycles. This preset frequency may be changed to any other designated frequency within the range by changing crystals and changing transmitting tuning switches, and realigning the set, according to the directions given in Section VI. The frequencies of the crystals supplied are given in Table IV, together with the positions of switches S-301, S-302, S-303, and S-207 for each frequency. The stability of the carrier frequency is plus or minus 0.01 percent, and the stability of the audio frequency is plus or minus one percent.

TABLE IV

CRYSTAL FREQUENCIES

Carrier Frequency in Megacycles	Crystal Frequency in Kilocycles	Crystal Code (Type CR-1A/AR)	Position of Switches S-207, S-301, S-302 and S-303
50.2596	4188.3	B7T	Black
50.9796	4248.3	B9T	Black
51.6396	4303.3	C1T	Black
52.3596	4363.3	C3T	Black
53.1796	4423.3	C5T	Black
53.7396	4478.3	C7T	Black
54.3996	4533.3	C9T	Black
55.5996	4633.3	C10T	Black
56.6796	4723.3	D3T	Black

TABLE IV (Cont.)

CRYSTAL FREQUENCIES

Carrier Frequency in Megacycles	Crystal Frequency in Kilocycles	Crystal Code (Type CR-1A/AR)	Position of Switches S-207, S-301, S-302 and S-303
57.6996	4808.3	D6T	Black
58.3596	4863.3	D8T	Black
59.1276	4927.3	D10T	Black
59.8596	4988.3	E2T	Black
60.5676	5047.3	E4T	Black
61.4196	5118.3	E6T	Black
62.400	5200.	Special	Black
63.600	5300.	Special	Black
64.500	5375.	Special	Black
65.100	5425.	Special	Black
65.940	5495.	A1T	Black
66.390	5532.5	A2T	Black
67.020	5585.	A3T	Black
67.560	5630.	A4T	Black
68.010	5667.5	A5T	Black
68.550	5712.5	A6T	Black
69.360	5780.	A7T	Black
70.170	5847.5	A8T	Red
70.800	3933.3	A9T	Red
71.250	3958.3	A10T	Red
71.790	3988.3	B1T	Red
72.780	4043.3	B2T	Red
73.3875	4077.1	B3T	Red
73.950	4108.3	B4T	Red
74.400	4133.3	B5T	Red
74.850	4158.3	B6T	Red
75.390	4188.3	B7T	Red
75.930	4218.3	B8T	Red
76.470	4248.3	B9T	Red
77.010	4278.3	B10T	Red
77.460	4303.3	C1T	Red
78.090	4338.3	C2T	Red
78.540	4363.3	C3T	Red
79.170	4398.3	C4T	Red
79.620	4423.3	C5T	Red
80.160	4453.3	C6T	Red
80.610	4478.3	C7T	Red
81.060	4503.3	C8T	Red
81.600	4533.3	C9T	Red
83.400	4633.3	C10T	Red
83.940	4663.3	D1T	Red
84.390	4688.3	D2T	Red
85.020	4723.3	D3T	Red
85.470	4748.3	D4T	Red
86.010	4778.3	D5T	Red
86.550	4808.3	D6T	Red
87.000	4833.3	D7T	Red
87.450	4863.3	D8T	Red
88.080	4893.3	D9T	Red
88.692	4927.3	D10T	Red
89.250	4958.3	E1T	Red
89.790	4988.3	E2T	Red
90.2625	5014.5	E3T	Red
90.852	5047.3	E4T	Red
91.431	5079.5	E5T	Red
92.130	5118.3	E6T	Red
92.850	5158.3	E7T	Red

1—22. OUTPUT POWER. When Radio Transmitting Set (AN/URW-3A) is properly tuned and loaded, the output is 12 watts minimum with a 28-volt D-C input. It will deliver 10 watts with a 22-volt input.

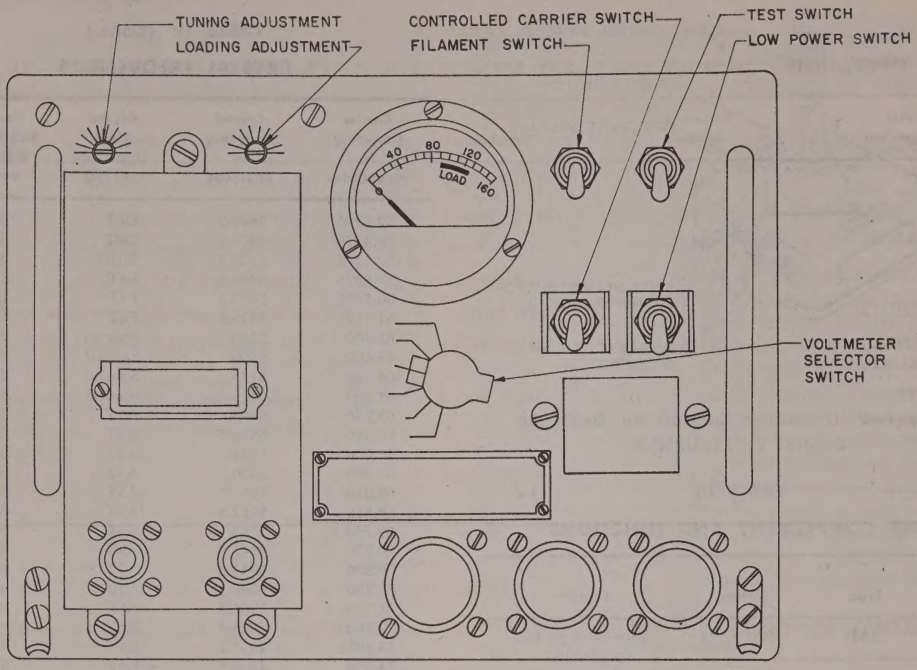


Figure 1–3. Operating Controls on Front of Radio Transmitter TS-421/URW-3A

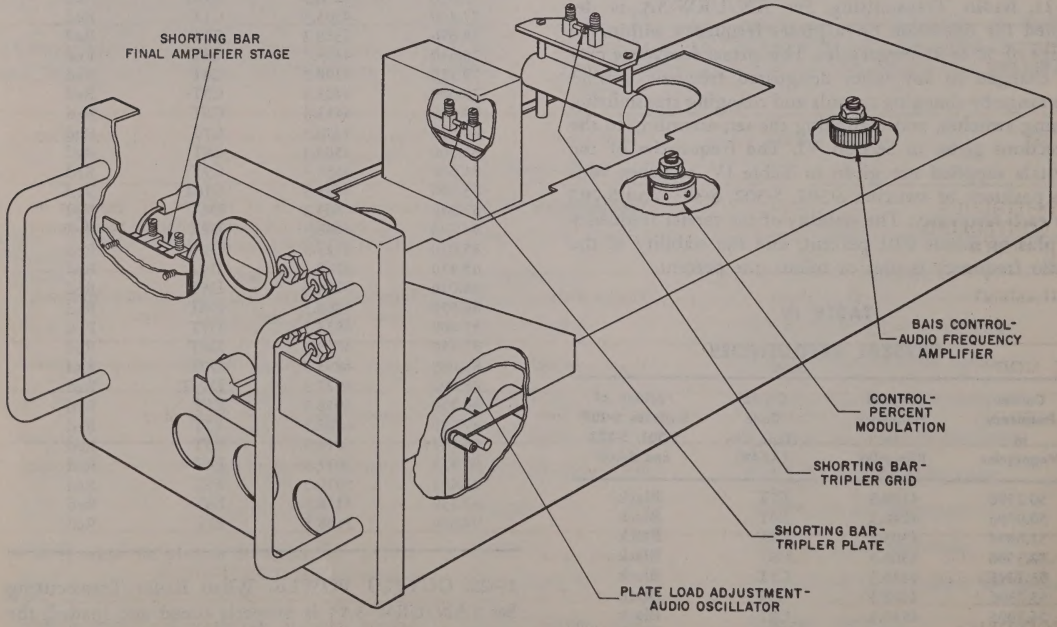


Figure 1–4. Operative Controls inside Radio Transmitter TS-421/URW-3A

TABLE V

OPERATING CONTROLS ON RADIO SET CONTROL C-711/URW-3 (See Figure 1—2)

Panel Designation	Reference Symbol	Description	Function
"RIGHT"	S101	Micro Switch	Grounds 300-cycle oscillator
"LEFT"	S102	Micro Switch	Grounds 650-cycle oscillator
"UP"	S103	Micro Switch	Grounds 1390-cycle oscillator
"DOWN"	S104	Micro Switch	Grounds 3000-cycle oscillator
"PARACHUTE"	S105	Push Switch	Removes ground from 955-cycle oscillator
"STUDENT INSTRUCTOR"	S106	Toggle Switch	Transfers control from instructor to student
"CARRIER"	S107	Toggle Switch	Grounds starting relay for dynamotor
"TELEPHONE JACK"	J101	Jack	Monitor audio tones
"INCREASE OUTPUT"	R101	Potentiometer	Audio tone volume control

TABLE VI

OPERATING CONTROLS ON RADIO TRANSMITTER TS-421/URW-3 (See Figures 1—3 and 1—4)

Control Designation	Reference Symbol	Description	Function
NORMAL-LOW POWER	S201	Toggle Switch	Allows transmitter to operate at normal power or decrease output — spring returns to "NORMAL"
METER SELECT	S202	Multipoint Selector Switch	Connects milliammeter M201 to selected points on transmitter
TEST	S203	Toggle Switch	Grounds one side of relays K-501 and K-502. Spring returns to OFF
CONTINUOUS-CONTROLLED CARRIER	S204	Toggle Switch	Grounds one side of relay K-501. Remains on "CONTINUOUS" when Radio Set Control C-711/URW-3 is used
FILAMENT	S205	Toggle Switch	Supplies 28 volts, D-C, for all tube filaments, bias voltages, and relay voltages
% MOD	S206	Toggle Switch	Selects either 60% or 90% modulation of carrier
ANTENNA	S207	Movable Link	Connects low or high band filter
	S301 S302 S303	Shorting bars	Changes frequency range of tanks of r-f circuits
LOW POWER % MOD ADJ	R248	Potentiometer	Adjusts percentage of modulation when transmitter is on "LOW POWER"
MOD DRIVE BALANCE ADJ	R235	Potentiometer	Adjusts input to modulator for minimum distortion

1–23. DYNAMOTOR DATA. A type DA-19A Dynamotor, manufactured by the Bendix Corporation, and modified by the New London Instrument Company is used in Dynamotor Unit PE-186C. It is rated as follows:

Input 28 volts, D-C, about 11 amperes, Continuous-duty output 400 volts, D-C, plus or minus 3 percent, 400 milliamperes.

1–24. POWER REQUIRED DATA.

Total Normal Operating	28 volts, D-C	14 amperes
Filament	28 volts, D-C	2.3 amperes
Dynamotor	28 volts, D-C	11 amperes
Standby current	28 volts, D-C	2.3 amperes

Maximum starting current 30 amperes

1–25. OPERATING CONTROLS. Operating and adjustment controls used in normal operation are found on Radio Set Control C-711/URW-3, and on Radio Transmitter TS-421/URW. They are listed in Tables V and VI.

SECTION II
PREPARATION FOR USE AND RESHIPMENT

2–1. Upon receipt of the package containing Radio Transmitting Set AN/URW-3A, inspect the packing cases for any obvious damage to the package. There are three large cardboard cartons, which fit one inside the other, to protect the units of the system. Each unit is also individually packaged before packing in the shipping carton.

Remove each unit from the carton, and from its own package, and inspect it carefully for tightness and physical damage.

2–2. See that the dynamotor unit rotor is free to rotate, and that the brushes seat properly. Check to see that the fuses are in place.

2–3. In the transmitter, see that there are no damaged components in the interior; check to see that all tubes are seated properly. Check switches for freedom of movement. See that the meter glass is not cracked, and that the meter pointer moves when the meter is tapped gently.

2–4. After being sure that all units are not damaged, connect the units as explained in Chapter V. Insert the proper crystal for the desired frequency. Tune and load the transmitter as explained in Chapter VI. The transmitter is ready for operation.

2–5. In packing the units for reshipment, they should be packed as shown in Figure 2–1. The arrows in the illustration indicate the front of the units.

2–6. Radio Transmitter TS-421/URW is put into the crate first, on top of a cardboard cushion, which acts as a shock absorber. The transmitter is assembled on its mount before being put into the case. The dynamotor is put into the crate next to the transmitter, on top of a cardboard cushion, and with another cardboard cushion between the dynamotor and the transmitter.

2–7. Crystal case CS-151 is put into the crate next to the dynamotor, and on top of it are laid the coils of interconnecting cable. The antenna is laid down with its base in the corner next to the Radio Transmitter TS-421/URW, and the whip extending the length of the crate. The two control units are laid in next to the antenna base, with the control handle upright next to the antenna whip.

2–8. Cardboard spacers are inserted as necessary to hold the units securely in place. After the units are packed into the crates, the crate is put inside another container, and this in turn is put into a third container.

2–9. In the event of malfunction of a transmitter set, the unit may be checked out by going through the analysis outlined in Chapter VI.

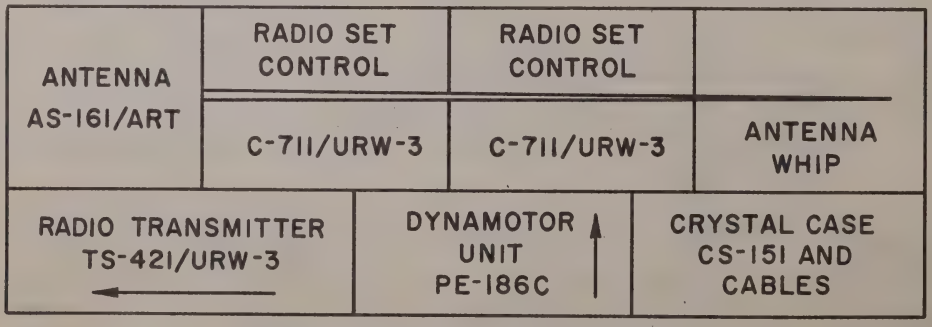


Figure 2–1. Units Assembled for Shipping

SECTION III
TEST EQUIPMENT AND TOOLS

3–1. TEST EQUIPMENT. The test equipment required for the testing of Radio Transmitting Set AN/URW-3A is listed in Table VII.

3–2. SPECIAL TOOLS. No special tools are required for maintenance of Radio Transmitting Set AN/URW-3A.

TABLE VII

TEST EQUIPMENT

Part or Type Number	Nomenclature	Application
IS-89 (Part of Test Equipment IE-13) or equivalent	Voltmeter	Measuring Voltages
Hewlett-Packard 410-B or equivalent	Vacuum-tube Voltmeter	Measuring Voltages and Resistances
	Audio Oscillator	Audio-frequency check
Dumont 108 or equivalent	Oscilloscope	Checking modulation envelope and audio-frequency circuits
HS-23 or HS-33	Headset	Checking audio output
IS-177	Tube Tester	Testing tubes

SECTION IV
THEORY OF OPERATION

4–1. SYSTEM ANALYSIS. The schematic diagrams and photographs in this book show the test points used in analysis of the principal parts of Radio Transmitting Set AN/URW-3A.

4–2. MAJOR TEST POINTS. The major test points are indicated by a star-encircled Arabic numeral, and will be referred to as test point 1, test point 2, etc. They check the operation of the audio circuits, the radio frequency circuits, and the power supply.

4–3. SECONDARY TEST POINTS. The secondary test points are indicated by an encircled capital letter and will be referred to as test point A, test point B, etc. They indicate the points used to isolate trouble to a component within one of the above-mentioned three principal areas.

4–4. MINOR TEST POINTS. The minor test points are identified by an encircled letter and Arabic numeral, and are referred to as test point A1, test point A2, etc. They are used to indicate the test points used in isolating causes of abnormal indication in the equipment.

4–5. INTERNAL CIRCUITS IN RADIO TRANSMITTER TS-421/URW. (See Figure 4–2.)

4–6. RADIO-FREQUENCY CIRCUITS. Three JAN-815 tubes (V-301, V-302, and V-303) are used in the R-F circuits. The JAN-815 tubes are two beam-power pentodes in one glass envelope, so the three tubes function as six.

4–7. The first half of tube V-301 serves as a quartz-crystal oscillator and a frequency-doubler, while the second half of the tube serves as a frequency doubler or tripler, depending on whether switch S301 is set for the 50 to 70 or the 70 to 95 megacycle range.

4–8. Tube V-302 acts as a push-pull frequency tripler and drives tube V-303, connected push-pull, the final amplifier stage.

4–9. AUDIO-FREQUENCY CIRCUITS. Four JAN-5814A tubes (V-210 through V-213) serve as audio oscillators. Since the JAN-5814A tubes are twin triodes, the four tubes function as eight, each one producing a different audio tone. The 475-cycle, 755-cycle, and 1900-cycle audio oscillators are not used in this equipment when controlled by the C-711/URW-3 Radio Set Control.

4–10. The signal from the operating oscillator tube is applied to the audio amplifier (V-214). This tube, another JAN-5814A, acts as a push-pull amplifier, and drives the modulator stage.

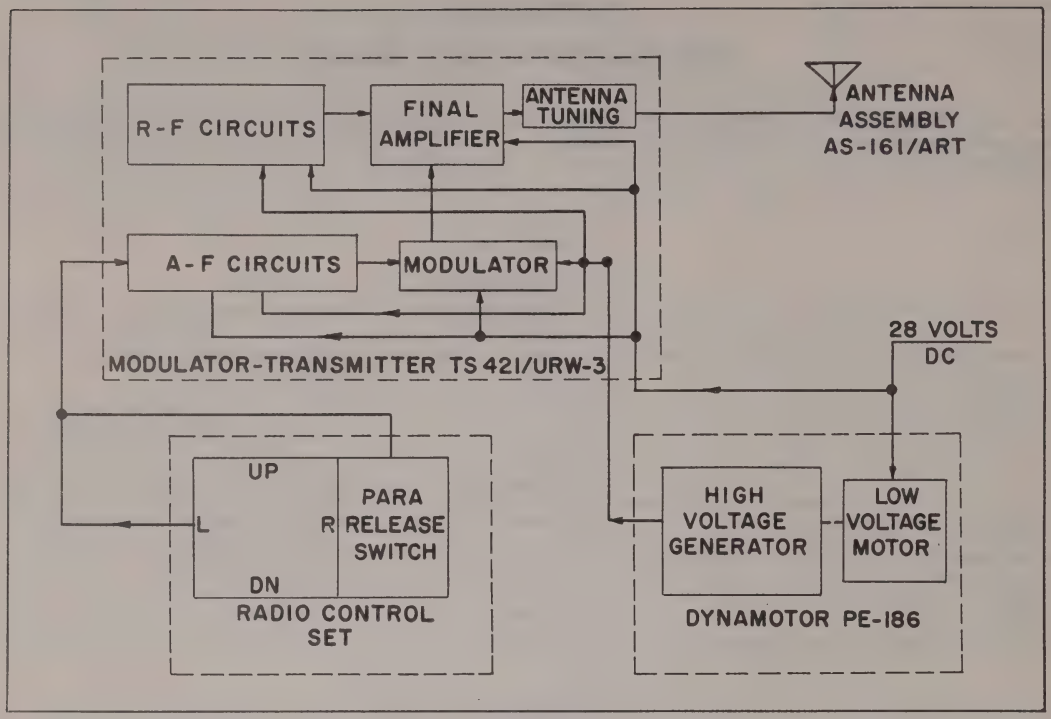


Figure 4—1. Radio Transmitting Set AN/URW-3A, Simplified Block Diagram

4—11. Two JAN-6L6WGB tubes (V-217 and V-218) operate in push-pull as the modulator stage. Their output modulates the final amplifier stage (V-303).

4—12. RADIO SET CONTROL C-711/URW-3. (See Figure 4—1.)

4—13. RADIO SET CONTROL C-711/URW-3 is used to control the output of Radio-Transmitter TS-421/URW The principal control element is the control stick, mounted upright on the square chassis of the control set. This control stick can be moved to any of four positions, marked "UP", "RIGHT", "DOWN", or "LEFT", or it may remain in the center (neutral) position. When the control switch is in the neutral position, a 955-cps (parachute) tone modulates the r-f carrier of the transmitter. The stick, when moved to any of the four marked positions, selects a different audio tone which modulates the r-f carrier of the transmitter, and, at the same time, removes the parachute tone. The four positions of the switch select four different audio tones. The tone is selected by the closing of a switch in the control set, which grounds the cathode of the selected audio oscillator. The marker for the positions "DOWN" and "UP" are imprinted on the reverse side with "FORWARD" and "REVERSE" respectively, for use with ground equipment.

4—14. Also mounted on Radio Set Control C-711/URW-3 are three other switches, marked "PARACHUTE", "CARRIER", and "STUDENT-INSTRUCTOR", respectively. The "PARACHUTE" switch, when depressed, removes the 955-cycle modulating tone from the r-f carrier, thus causing the release of the parachute from the airborne target. The "CARRIER" switch, together with the "FIL-ON" switch on Radio Transmitter TS-421/URW closes the relay in the motor circuit of the dynamotor unit, thus starting the dynamotor. A red jewel light on the control unit indicates when the "CARRIER" switch is in the "ON" position. The "STUDENT-INSTRUCTOR" switch transfers control of the transmitter set from the instructor to a student who has an identical control set. The "PARACHUTE" switch is imprinted on its reverse side with "STOP", for use with ground equipment.

4—15. A phone jack and a volume control on the control box are provided for aural monitoring of the audio tones.

4—16. DYNAMOTOR UNIT PE-186C. (See Figure 4—10.)

4—17. DYNAMOTOR UNIT PE-186C consists of field coils, and a rotor which carriers two sets of armature

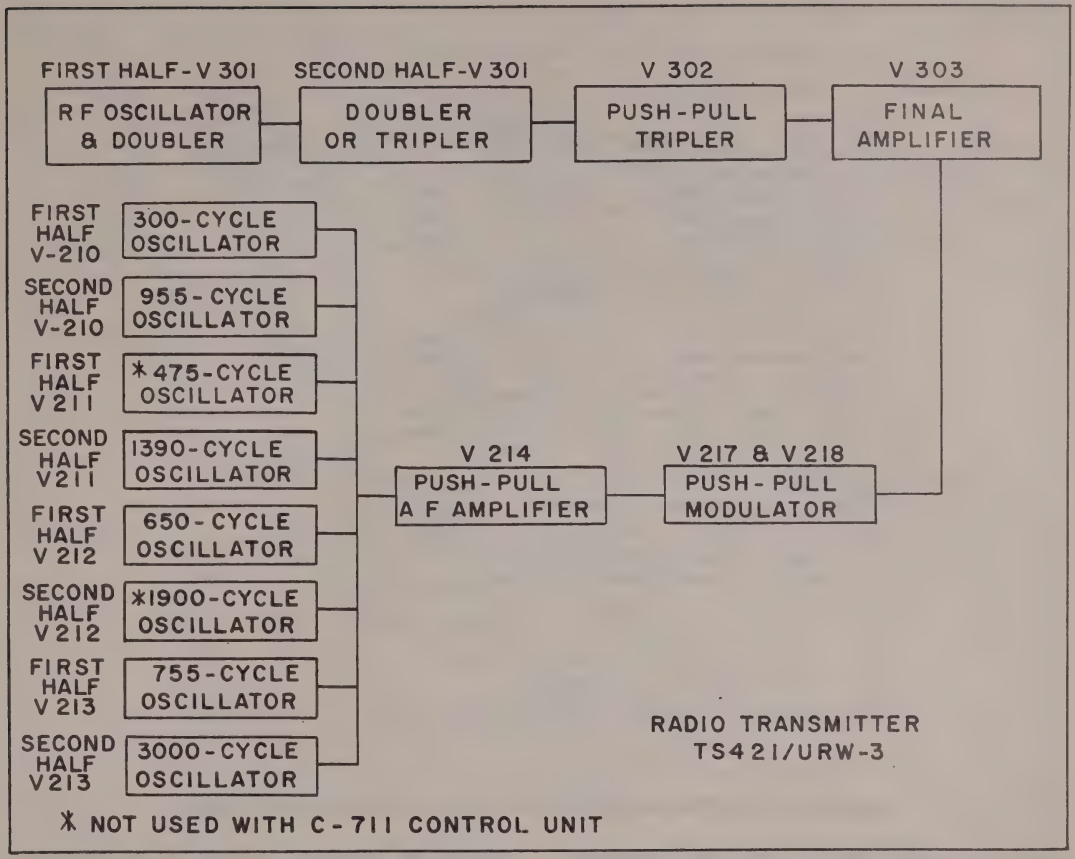


Figure 4–2. Radio Transmitter TS-421/URW Block Diagram

windings connected to different commutators. One winding is the armature of a shunt motor, while the other is the generator winding which supplies high-voltage to the transmitter set. The input is about 14 amperes at 28 volts, D-C, while the output is about 400 milliamps at 400 volts D-C. A filter network is incorporated into the dynamotor unit, to minimize noise or hash generated by the dynamotor. Fuses in both the high- and low-voltage circuits prevent overloading either circuit. The dynamotor starts when the "FIL-ON" switch on the modulator-transmitter is moved to the "ON" position, and then either the "TEST" switch on the modulator-transmitter of the "CARRIER" switch on the control unit is closed.

4–18. FUNCTIONAL OPERATION OF ELECTRONIC COMPONENTS IN RADIO TRANSMITTER TS-421/URW. (See Figure 4–2.)

4–19. RADIO-FREQUENCY CIRCUITS. In Radio Transmitter TS-421/URW, the chassis is separated into two major units: an r-f (carrier) circuit chassis and an a-f (modulator) circuit chassis. The transmitter tuning unit, mounted along one side of the transmitter chassis, is a removable section containing all the r-f stages of the transmitter. Switches connected to the tuning coils select either the 50 to 70 or the 70 to 95 range. The desired frequency in the selected range is obtained by inserting the correct crystal unit, setting the various coil switches, and tuning all the tank capacitors, as described in Section VI.

4–20. FREQUENCY MULTIPLICATION. Frequency multiplication is used to develop a crystal-controlled VHF frequency from a HF crystal. Class "C" amplifiers have a large harmonic content, so they may be used as frequency multipliers by tuning the plate tank circuit to the desired multiple of the control grid frequency.

4–21. For operation between 50 and 70 megacycles, the plate circuit of the crystal-controlled oscillator section of tube V-301 is tuned to twice the crystal frequency, the grid circuit of tube V-302 is tuned to twice the frequency of the plate in the preceding stage, and then the plate circuit of tube V302 is tuned to three times the

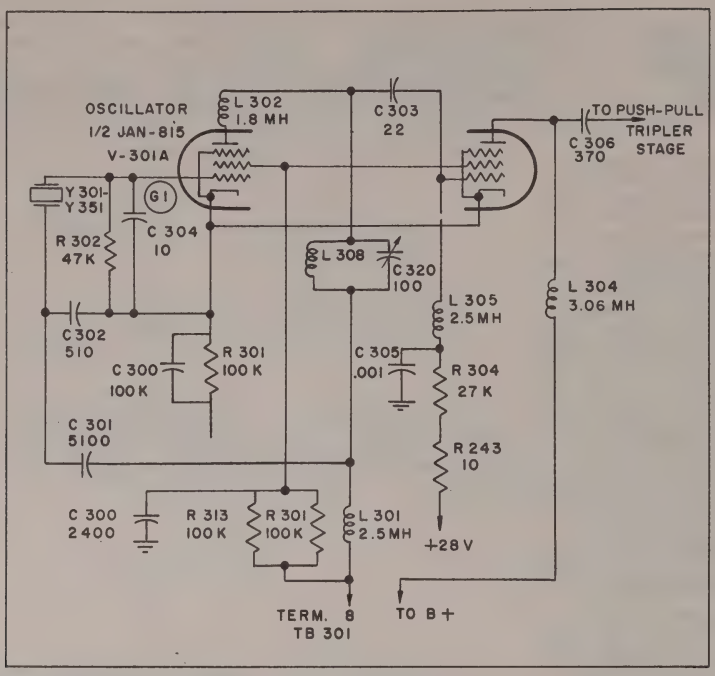


Figure 4—3. Simplified Schematic of Oscillator and Doubler-Tripler Stage

frequency of the grid circuit of tube V-302. The output stage, V303, has no frequency multiplication, but serves as a modulated Class "C" amplifier. The carrier frequency for this range is thus 12 times the crystal frequency; the crystal frequency is doubled in the first section of V-301, doubled again the second section of tube V-301, then tripled in the tripler stage (V-302).

4—22. For operation between 70 and 95 megacycles, the grid circuit of tube V-302 is tuned to three times the frequency of the plate in the preceding stage. The carrier frequency is thus 18 times the crystal frequency: The crystal frequency is doubled in the first section of tube V-301, tripled in the second section of tube V-301, and tripled again in the tripler stage (V-302).

4—23. OSCILLATOR AND DOUBLER OR TRIPLER STAGE. (See Figure 4—3.)

4—24. Coil L-308 and capacitor G-320 form the tank circuit for the first section of the first JAN-815 tube, V-301. They are tuned to the second harmonic of the frequency control crystal, Y-301 to Y-351. Capacitor C-301 feeds back part of the energy from the plate circuit to the grid circuit, to sustain oscillations. Capacitor C-302 helps to maintain the voltage feedback at a value safe for the crystal. The oscillator operates Class "C" and the bias voltage is developed in the grid resistor R-302. The bias present is a function of the activity of the crystal and the amount of feedback.

4—25. L-302 is a parasitic suppression choke, and capacitor C-303 is a coupling capacitor, which passes the oscillations developed in the first half of the tube on to the grid of the second half of tube V-301.

4—26. L-305 is a radio-frequency choke in the grid circuit of the second half of tube V-301. Resistor R-304 is the grid leak resistor, while resistor R-243 is a meter shunt. Resistors R-313 and R-301 are screen voltage-dropping resistors, while C-300 bypasses the screen to ground. All harmonics produced by the plate of the second section of tube V-301 are passed through capacitor C-306 to the grid tank of tube V-302 where the proper harmonic is selected.

4—27. PUSH-PULL TRIPLER. (See Figure 4—4.)

4—28. Coil L-309 and capacitor C-321 form the grid tank for the tripler stage (V-302). Switch S301 selects the proper frequency range. For the 50 to 70-megacycle range, the grid tank is tuned to the second harmonic of the plate circuit of the second half of tube V-301. For the 70 to 95-megacycle range, the grid tank of tube

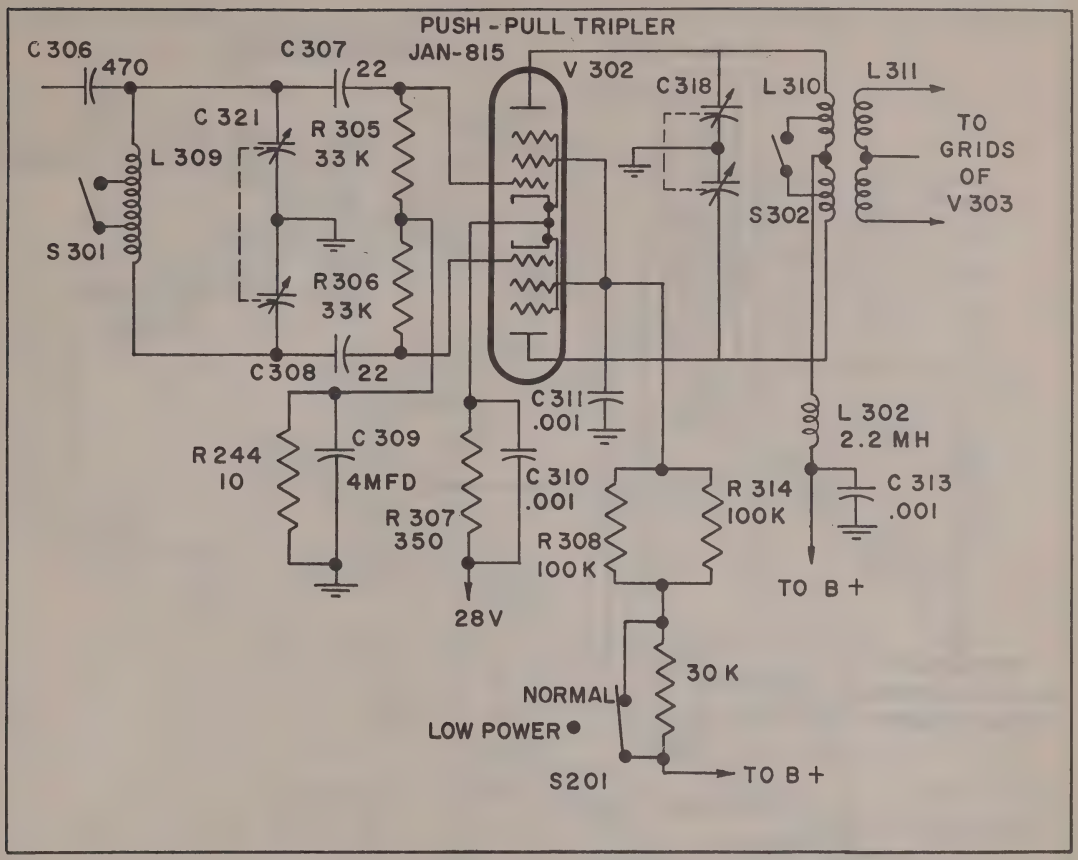


Figure 4–4. Simplified Schematic of Push-Pull Tripler Stage

V-302 is tuned to the third harmonic of the plate circuit of tube V-301.

4–29. The tripler stage is operated Class "C". The total bias for the stage is a combination of three voltages: the cathode is connected to the 28-volt tap (fixed bias) and is also biased by the drop in cathode resistor R-307. Additional bias is developed in grid resistors R-305 and R-306. R-244 is a meter shunt. Capacitors C-307 and C-308 are coupling capacitors which pass the oscillations developed in the grid tank on to the grids of tube V-302.

4–30. The plate tank circuit consists of coil L-310 and capacitor C-318. Switch S-302 selects the proper frequency range and capacitor C-318 tunes the tank circuit to three times the grid frequency. Coil L-303 is a parasitic suppression choke. Resistors R-308 and R-314 are screen dropping resistors. Capacitors C-311 and C-313 are bypass capacitors for the screen and plate respectively. Switch S-201 connects the screen circuit to B+ directly ("NORMAL"), or to B+ through a 30K voltage-dropping resistor ("LOW POWER"). The 30K resistor shown is actually a parallel connection of five 150K resistors (R252, R253, R254, R255, R256).

4–31. FINAL AMPLIFIER. (See Figure 4–5.)

4–32. Capacitor C-322 tunes coil L-311 to the final radio frequency. This stage operates Class "C". No fixed bias is used in this stage, the bias being developed across grid leak resistors R-309, and also in cathode resistor R-311. Resistor R-242 is a meter shunt capacitor. C-316 is a cathode by-pass. The screen voltage is supplied through dropping resistor R-310. Capacitor C-312 is the screen bypass. Coil L-307 is a parasitic suppressor choke in the plate circuit. Capacitor C-315 is a plate bypass. Switch S-201, in the "NORMAL" position, connects the screens and plates of V-303 to B+ in series with the secondary of the modulation transformer. In the "LOW POWER" position, S201 inserts the 30K dropping resistor in series with this circuit. In the "LOW POWER" position, resistors R-248 and R-276 are placed in parallel with the modulation transformer secondary, thus weakening the modulation signal at the same time the B+

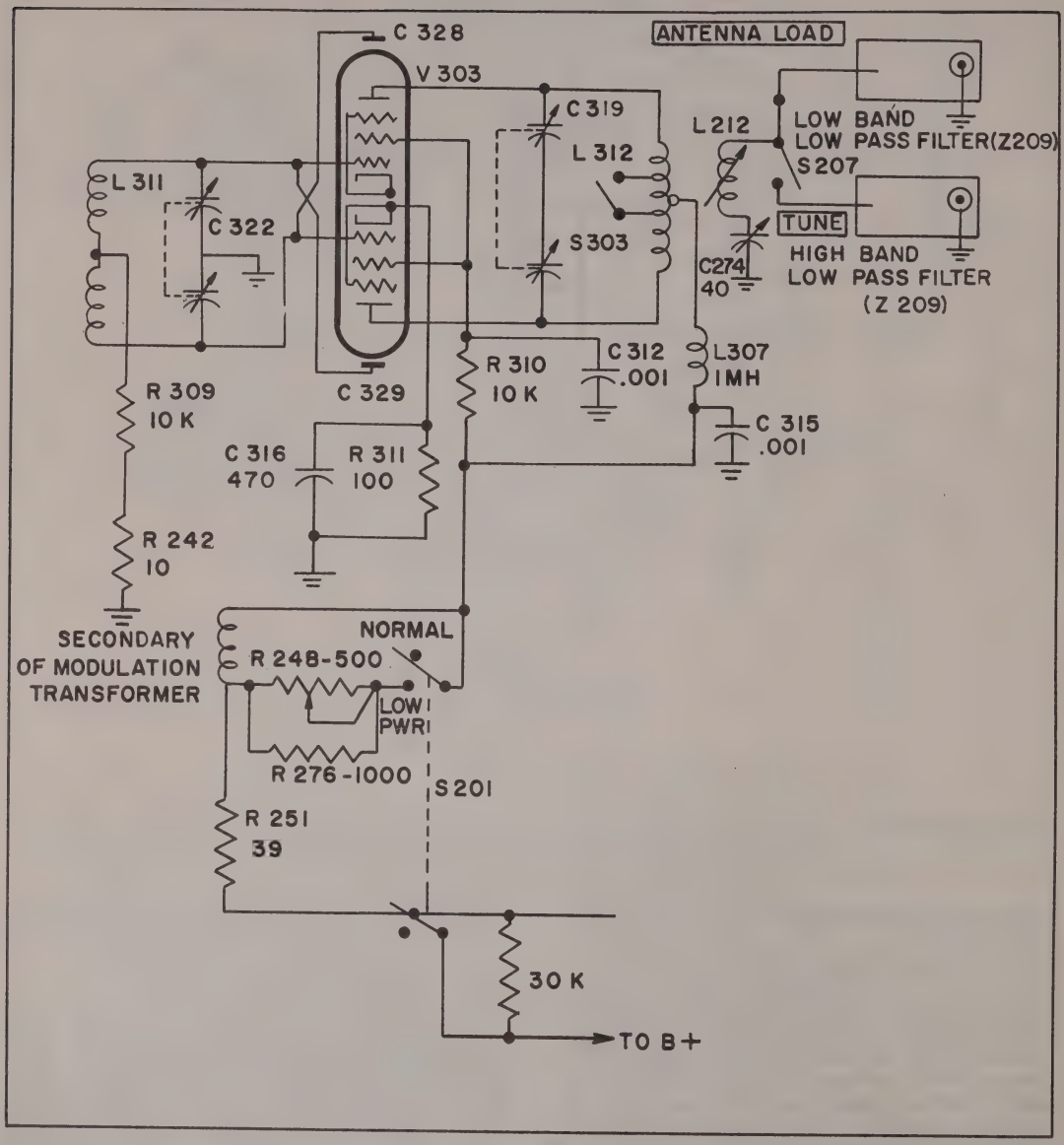


Figure 4–5. Simplified Schematic of Final Amplifier Stage and Antenna Loading Network

voltage is decreased. R-248 is variable, and adjusts the percentage modulation when the transmitter is on low power.

4–33. Class "C" amplifiers are subject to self-oscillation when the grid-to-plate interelectrode capacitance is large enough to feed back enough energy to supply grid circuit losses. Where a push-pull circuit is used, this tendency toward oscillation may be overcome by connecting each grid to the opposite plate through a capacitance equal to the sum of the grid-to-plate capacitance and the grid-plate circuit capacitance. The neutralizing capacitors used here are C-328 and C-329. They are placed outside the tube element, but near enough to the tube plates to neutralize the final amplifier stage. The capacitor plates consist of an aluminum angle with rounded corners. The aluminum is mounted on a

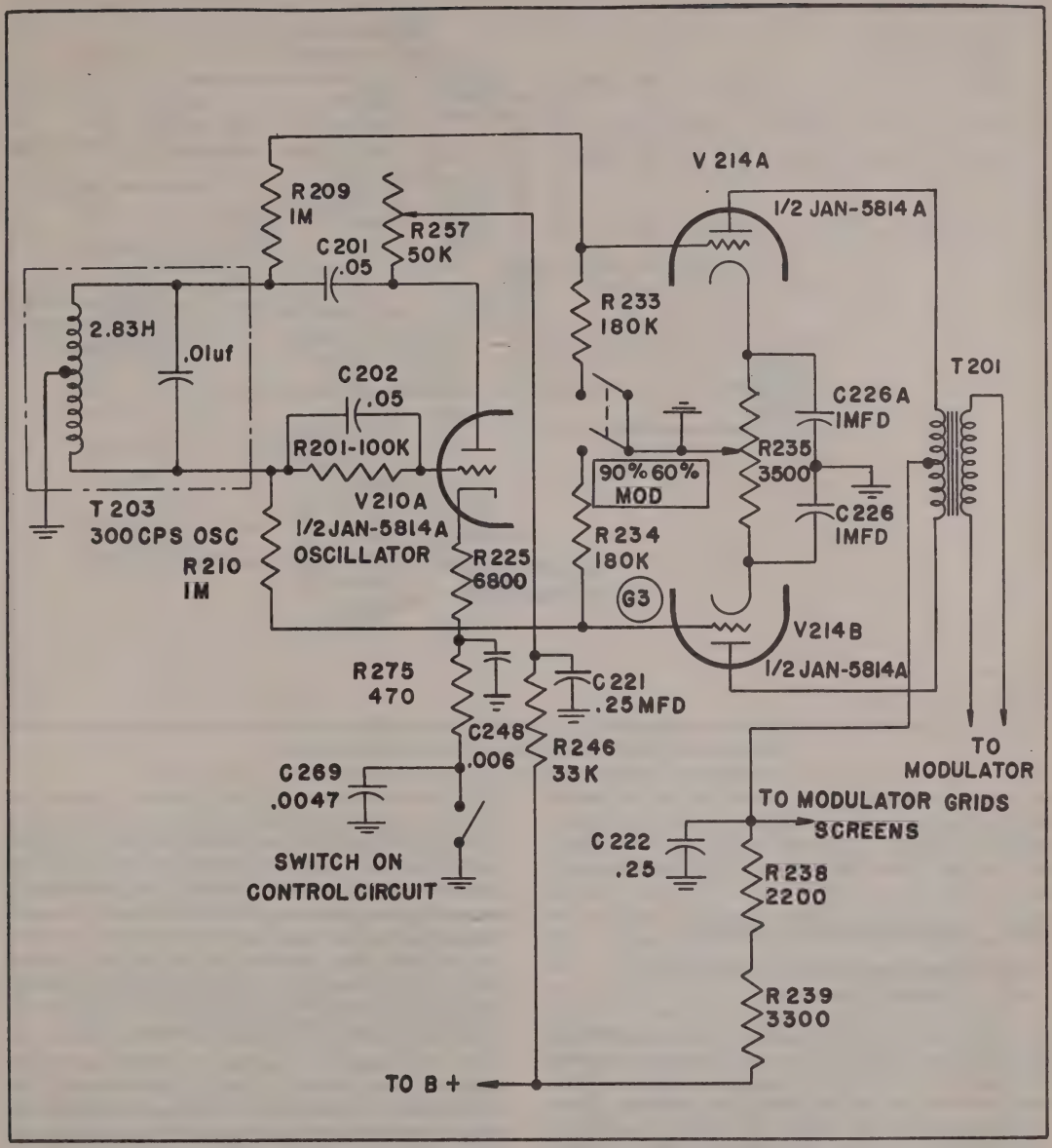


Figure 4–6. Simplified Schematic of Audio Oscillator and Audio Amplifier Stages

ceramic feed-through insulator, and is held by a nut on top. The mounting hole of the angle is in a horizontal plane, so it is possible to vary the distance of the vertical plane of the angle from the vacuum tube (and thus change capacitance) by loosening the nut and rotating the angle upon its mount. When the correct setting is found, the nut is tightened to maintain it. Only in rare cases will it be necessary to make any adjustment.

4–34. Capacitor C-319 and Coil L-313 form the plate tank circuit of the final amplifier stage. Switch S-303 selects the proper frequency range, and C-319 tunes the stage.

4–35. ANTENNA CIRCUIT. (See Figure 4–5.) Power from the final plate tank is coupled to the antenna circuit through coil L-212. Capacitor C-274 serves to tune

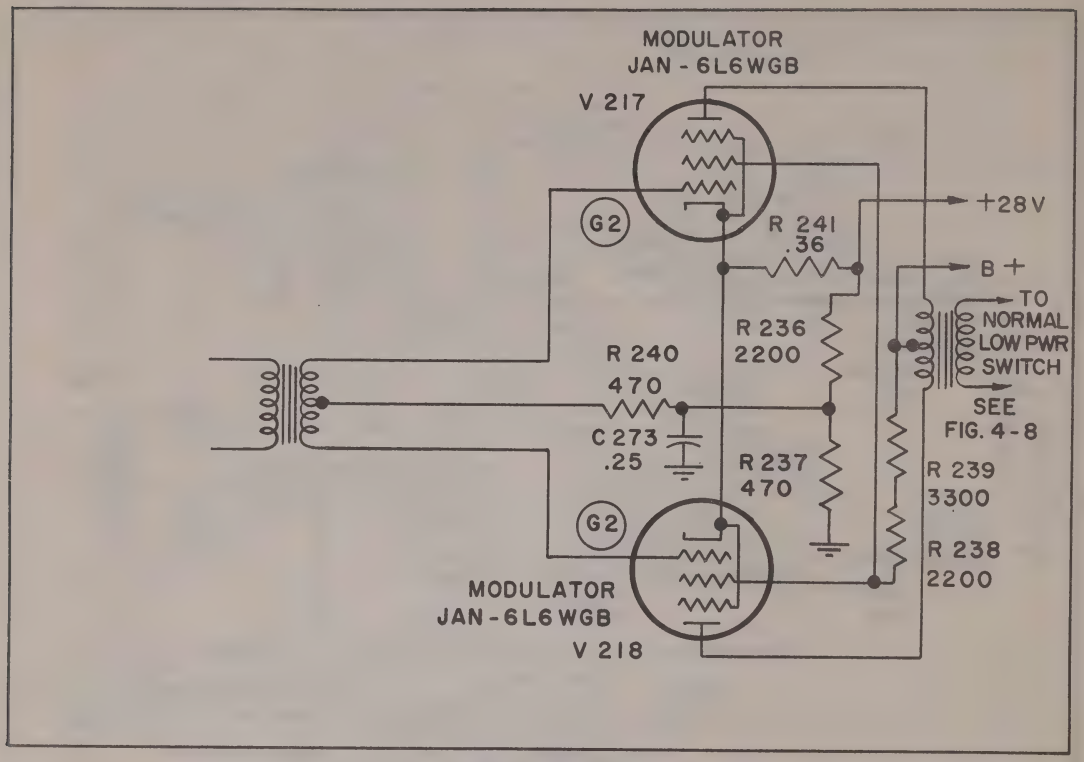


Figure 4—7. Simplified Schematic of Modulator Station

the antenna coil, and L-212 is varied to load it. Switch S-207 selects either the low-frequency filter or the high-frequency filter to connect to the antenna. The filters are low-pass filters designed to eliminate harmonic interference.

4—36. AUDIO-FREQUENCY CIRCUITS.

4—37. AUDIO TONE OSCILLATORS. (See Figure 4—6.)

4—38. Each audio oscillator uses 1/2 of a Jan-5814A tube (V-210 to V-213). The audio frequency of each oscillator is determined by the capacitance and inductance mounted in the oscillator coil assembly. Eight oscillator circuits are present in Radio Transmitter TS-421/URW. They are for 300, 475, 650, 755, 955, 1390, 1900, and 3000 cps. The 300-cycle oscillator is discussed as being typical, since only the electrical values of components differ in the eight oscillators.

4—39. The plate load impedance for the tube is resistors R-257. R-257 is adjusted to give proper audio level control. It determines the percentage modulation by the 300-cycle oscillator. C-201 feeds the voltage back to keep the circuit oscillating. Resistor R-201 is a grid leak resistor, and capacitor C-202 is the grid leak bypass. Resistors R-225 and R-275 are cathode resistors. Capacitor C-269 is a radio-frequency filter capacitor. Bias for the stage is developed in resistors R-225 and R-275. R-209 and R-310 are coupling resistors between the oscillator and the push-pull audio amplifier stage. The single-tube oscillator is used to drive a push-pull amplifier stage by connecting one push-pull grid to the plate of the oscillator, and the other push-pull grid to the grid circuit of the oscillator. Since the signal on the grid of a vacuum tube is 180 degrees out from the plate voltage, the push-pull grids in tube V214 receive voltages that are displaced the necessary 180 degrees from one another.

4—40. The cathode circuit for the audio oscillator is open until the switch is closed in Radio Set Control C-711/URW-3, connecting the selected cathode to ground. When the cathode is grounded, the selected tube operates. Since the plates and grids of all the audio oscillators are permanently resistance-coupled to the grids of the push-pull audio amplifier, the signal is automatically fed into the amplifier stage, from any tube whose cathode circuit is grounded.

Note

The 475-cycle, 755-cycle, and 1900-cycle oscillators are used in Radio Transmitter TS-421/URW-3 when it is used with Radio Set Control BC-1156.

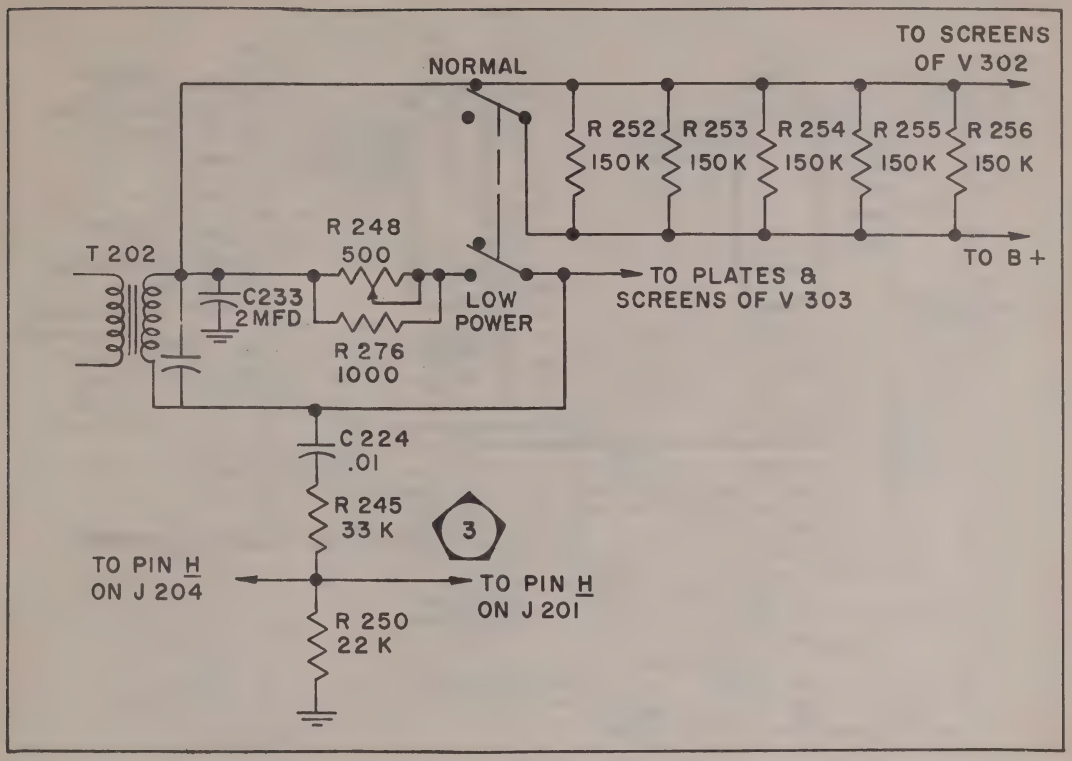


Figure 4–8. Simplified Schematic of "NORMAL-LOW POWER" Switch Circuit

4–41. The audio frequency amplifier operates push-pull, using the two sections of the twin triode V-214, a JAN-5814A tube. The push-pull amplifier is operated Class A , and its bias is developed in R-235. Capacitors C-226 and C-226A are cathode bypass capacitors. R-238 and R-239 are plate voltage-dropping resistors, and also screen-dropping resistors for the modulator stage. C-222 is a plate bypass. T-201 is a coupling transformer between the audio amplifier and the modulator stage. Potentiometer R-235 is adjusted for minimum distortion. Grid leak is through resistors R-233 and R-234 when switch S-206 is closed; when switch S-206 is open, the grid leak is through resistors R-209 and R-210 and through the oscillator coil to ground. Capacitors C-226 and C-226A are cathode bypass capacitors.

4–42. PER CENT MODULATION SWITCH. The output from the audio oscillator stage is coupled direct to the grids of the audio amplifier stage when the "MODULATION" switch is left on "90%". However when the "MODULATION" switch is put on "60%", resistors R-233 and R-234, together with R-209 and R-210, form a voltage-dividing network, and this decreases the oscillator signal to the grids of tube V214.

4–43. MODULATOR. (See Figure 4–7.) The Class AB1 push-pull modulation stage uses two JAN-6L6WGB tubes (V217 and V218). The signal input to the stage is through transformer T201. The fixed bias is from the junction of voltage-dividing resistors R-236 and R-237, on the 28-volt supply. Additional bias is derived from cathode resistor R236. The capacitor C219 across the transformer T201 secondary reduces the harmonic content of the higher audio frequences thus reducing distortion. The modulator is coupled through transformer T202 to the plates and screens of the final amplifier tube V303.

4–44. "NORMAL LOW-POWER" SWITCH. (See Figure 4–8.) Transformer T202 secondary is connected in series with B+ when the "NORMAL-LOW POWER" switch is on "NORMAL". When that switch is on "LOW POWER", the B+ is supplied through the voltage-dropping bank of resistors R252, R253, R254, R255, and R256. In the "LOW POWER" position, the modulation transformer (T202) secondary is shunted by resistors R-248 and R-276, thus decreasing the strength of the modulation signal delivered to tube V-303. R-248 adjusts the carrier modulation when the switch is in the "LOW POWER" position.

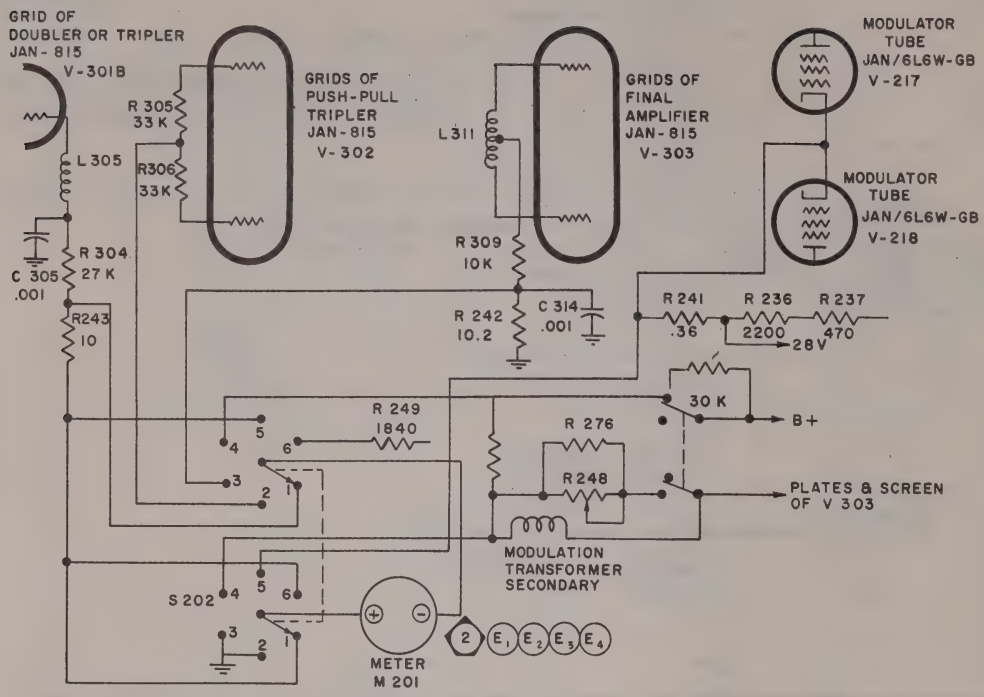


Figure 4–9. Simplified Schematic of Meter Circuits

4–45. METER CIRCUITS. (See Figure 4–9.)

4–46. Milliammeter M201 is a D-C meter. The meter movement is connected by switch S-202, in parallel with one of five different resistors to measure the current flowing in different parts of the transmitter. The sixth position measures the D-C supply voltage to the dynamotor.

4–47. In position one, "DOUBLER GRID", this meter is connected across the resistor R-243, in the grid circuit of the second section of tube V-301.

4–48. In position two, "TRIPLER GRID", the meter is connected across the resistor R-244 in the grid circuit of tube V-302.

4–49. In position three, "FINAL GRID", the meter is connected across the resistor R-242, in the grid circuit of tube V-303.

4–50. In position four, "FINAL PLATE", the meter is connected across resistor R-251, which is in the circuit between B+ and the plate of tube V303.

4–51. In position five, "LOAD LEVEL", the meter is connected in series with resistor R-249 between the 28-volt D-C point and ground. If the 28-volt source is low, the meter will indicate below the "LOAD" range. The meter indicates the point to which the meter should be adjusted when loading the transmitter.

4–52. In position six, "MOD PLATE", the meter is connected across resistor R-248, through which passes all plate current for both tubes V-217 and V-218.

4–53. FUNCTIONAL OPERATION OF DYNAMOTOR UNIT PE-186C. (See Figure 4–10.)

4–54. Within this dynamotor unit are the motor-generator, control relays, noise filters, capacitors, a high-voltage fuse and a low-voltage fuse. The dynamotor consists of field coils and a rotor which carries two sets of armature windings. The low-voltage (28-volt) winding serves as the armature of a shunt motor. The other winding supplies the high-voltage output, which is approximately 400 volts D-C.

4–55. When switch S-205, "FIL-OFF", is moved to the "FIL" position, 28 volts D-C is supplied to the tube heaters and to the positive end of the actuating coil of relay K-502. The negative end of relay K-502 is grounded when the "TEST" switch (S203), or the "CARRIER" switch on Radio Set Control C-711/URW-3 is closed. When relay K-502 closes, it applies

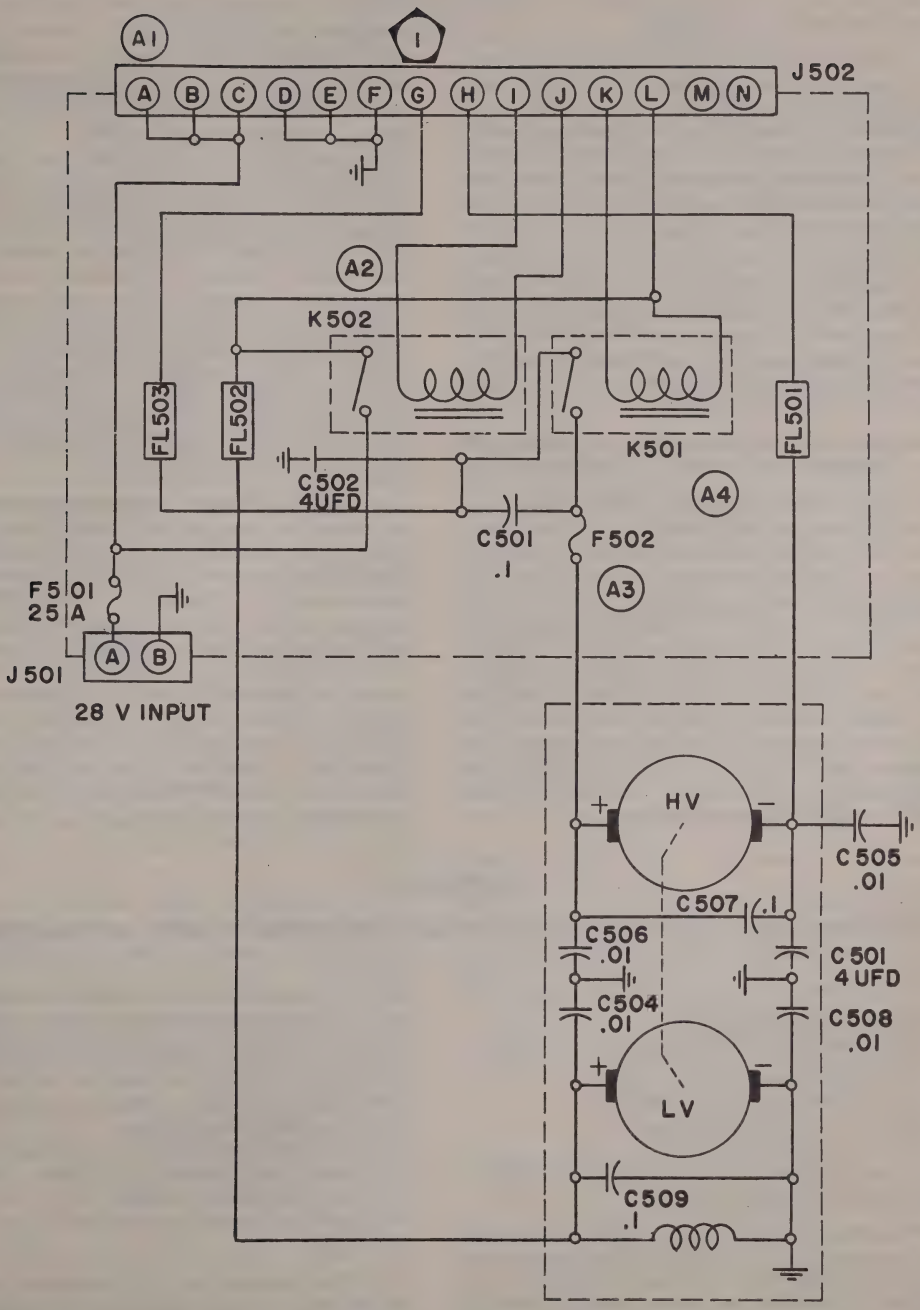


Figure 4—10. Simplified Schematic of Dynamotor Unit

voltage to fan motor B-201, and to the dynamotor. It also completes the circuit to the "CARRIER ON" light on Radio Set Control C-711/URW-3.

4—56. When relay K-502 closes, it also supplies voltage to the positive end of relay K-501. Relay K-501 will operate then, because the negative end of its coil is grounded through S204 in Radio Transmitter TS-421/URW. (S-204 is always left in the "CONTINUOUS CARRIER" position.) Relay K-501 then operates, and connects the high-voltage output of the dynamotor to the output terminal, G, through fuse F502 and filter FL503.

4—57. Two values of voltage are taken from the dynamotor unit. 400 volts is taken from the output of the dynamotor, while 28 volts is taken through the unit, from the 28-volt input. The low-voltage input and output are protected by fuse F-501, while the high-voltage output is protected by fuse F-502.

4—58. FUNCTIONAL OPERATION OF RADIO SET CONTROL C-711/URW-3. (See Figure 1—2.)

4—59. Seven switches, an indicator light, a volume control, and a phone jack are mounted on the control set. Four of the switches are actuated by the control stick mounted on the box; they are actuated individually when the stick is moved to "RIGHT", "LEFT", "UP", or "DOWN". They are single-pole, double-throw switches with a spring-return to one pole. The "PARACHUTE" switch is a normally closed pushbutton switch. The "CARRIER" switch is a double-pole, single-throw switch, while the "STUDENT-INSTRUCTOR" switch is a double-pole, double-throw switch. The nameplates "DOWN", "UP", and "CARRIER" are inscribed on their reverse with "FORWARD", "REVERSE", and "STOP", respectively.

4—60. The normally-closed contacts of the four stick-actuated switches are in series with the "PARACHUTE" switch and the "INSTRUCTOR" contacts of the "INSTRUCTOR-STUDENT" switch, from terminal D to terminal G (ground) of J103. This grounds the cathode of the 955-cycle oscillator, tube V-210B, and causes Radio Transmitter TS-421/URW to transmit an r-f carrier modulated with a 955-cycle tone. Moving the control stick out of neutral into any other position disconnects the cathode of V210B from ground, and connects the cathode of V-210A, V-211B, V-212A, or V-213B to ground. Thus, when the control stick is in the "RIGHT" position V-210A starts oscillating, and the carrier is modulated with a 300-cycle tone. In the "LEFT" position, V-212A starts oscillating, and the carrier is modulated with a 650-cycle tone. In the "UP" position V-211B is oscillating, and the carrier is modulated with a 1390-cycle tone. In the "DOWN" position, V-213B is oscillating, and the carrier is modulated with a 3000-cycle tone. Pressing the "PARACHUTE" switch removes all tones from the carrier.

4—61. The "CARRIER" switch completes the circuit to ground for relay K-502, causing K-502 to close, starting the dynamotor. A red light, mounted on the cabinet, lights when the "CARRIER" switch and relay K502 close. The "STUDENT-INSTRUCTOR" switch transfers control of the transmitter from the instructor to a student who has an identical radio set control. When the switch is on "STUDENT", all controls except the "CARRIER" switch are disconnected from ground. A phone jack and a volume control are provided for aural monitoring of the audio tones. The phone jack is connected to one leg of the modulation transformer secondary winding through capacitor C-224 and resistors R-245 and R-250.

SECTION V

DESCRIPTION OF SYSTEM TIE-IN OF EQUIPMENT AND ACCESSORIES

5—1. The following units are connected together to make a complete operating system:

1. Radio Transmitter TS-421/URW
2. Dynamotor Unit PE-186C
3. Radio Set Control C-711/URW-3
4. Antenna Assembly AS-161/ART

5—2. In addition Radio Set Control BC-1156/URW-3 may be connected into the system.

5—3. The radio transmitter connects directly to all other units through cables and plugs which are inserted into receptacles in the face of the radio transmitter. The receptacles are all along the bottom of the transmitter. From left to right the receptacles are as follows: on the left, on the low-pass filter unit, two receptacles for the antenna cable, one for the high-frequency and the other for the low-frequency band; in the middle the power supply (dynamotor PE-186C) cable receptacle; to the right of that the receptacle for control unit BC-1156/URW-3; and on the extreme right, the receptacle for radio set control unit C-711/URW-3. See Figure 4—1.

5—4. The cables which connect the other units to the radio transmitter are as follows:

1. Dynamotor unit PE-186C, cable CX-1254/U
2. Radio Set Control C-711/URW-3, cable CX-1253/U, 20 feet or 100 feet
3. Antenna Assembly AS-161/ART, type RG8/U cable

5—5. The dynamotor unit is connected to a 28-volt D-C supply source through cable CD-871. Facing the front of the dynamotor unit, the receptacle on the right connects to the Radio Transmitter TS-421/URW, while the left-hand receptacle connects to the 28-volt D-C source.

SECTION VI
INSTRUCTIONS FOR CHECKOUT OR ANALYSIS

6—1. MINIMUM PERFORMANCE STANDARDS.

6—2. RADIO OUTPUT. Radio Transmitting Set AN/URW-3A is rated at 12 watts output when the supply voltage is 28 volts D-C. However, the transmitter is rated at a minimum of 10 watts with an input of 22 volts. The output is measured by means of a TS-118/AP wattmeter.

6—3. AUDIO FREQUENCY CHECK. (See Figure 7—3.) The frequency of each of the audio oscillators should be within 1% of the rated frequency for the coil. The frequency is checked by comparing it, on an oscilloscope, with a known frequency. The audio oscillator used to check the audio frequency output will probably not be accurate to better than 2%. The accuracy of the oscillator will therefore determine the permissible limits of reading obtained with this arrangement.

The test equipment is set up as follows:

a. Connect pin H of J201 to the vertical amplifier of an oscilloscope.

b. Connect an accurately calibrated audio oscillator to the horizontal plates of the oscilloscope.

6—4. To make a frequency check, proceed as follows:

a. Turn the "FIL-OFF" switch to "FIL", and after 30 seconds, push the "TEST" button.

b. Short pin A on J-201 to ground.

c. Adjust the amplitude of the oscilloscope and the frequency of the audio oscillator until a stationary circle is obtained.

d. Read the frequency shown on the dial of the oscillator. A is shorted to ground, the frequency should be 300 cycles plus or minus one percent. The oscillator should read between 294 and 306 cycles if it is accurate to two percent.

e. Remove the short from pin A, and short pin C. Proceed as in steps c and d above, except that the frequency should be 650 cycles plus or minus one percent.

f. Remove the short from pin C, and short pin D. Proceed as in steps c and d above, except that the frequency should be 955 cycles plus or minus one percent.

g. Remove the short from pin D, and short pin E. Proceed as in steps c and d above, except that the frequency should be 1390 cycles plus or minus one percent.

h. Remove the short from pin E, and short pin F. Proceed as in steps c and d above, except that the frequency should be 3000 cycles plus or minus one percent.

i. If any of the audio frequencies are found to be outside the tolerances given above, the tuned choke for that frequency (Z203 to Z210) should be replaced.

6—5. AUDIO OSCILLATORS AMPLITUDE CHECK. (See Figures 1—4 and 7—3.) The magnitude of the output of the audio oscillators and amplifiers should be such that, when the "90%-60% MOD" switch (S-206) is on "90%", the carrier should be modulated at 90 plus or minus 10 percent, that is, between 81 and 99 percent, and the "90%-60% MOD" switch is on 60%, the carrier should be modulated at 60 plus or minus 10 percent, that is, between 54 and 66 percent. The test equipment is set up as follows:

a. Couple several turns of wire around the antenna, with the coil ends connected to the ground and vertical terminals of an oscilloscope.

b. Disconnect the vertical amplifier of the oscilloscope. Vary the number of turns of wire around the antenna until a band approximately two inches wide is produced on the scope.

c. Set the modulation control switch (S-206) on "90".

6—6. To check the amplitude of the audio oscillator, proceed as follows:

a. Turn the "FIL-OFF" switch to "FIL", and thirty seconds later push the "TEST" button.

b. Short pin A on J201 to ground. This modulates the carrier with the 300-cycle note. The pattern shown on the screen should indicate 90 percent (plus or minus 10 percent) modulation. The present modulation can be determined by the following formula:

$$\text{Percent} = \frac{h_1 - h_2}{h_1 + h_2} \times 100$$

, where h_1 is the distance across the widest position of the modulation envelope, and h_2 is the distance across the narrowest portion of the modulation envelope, as it appears on the screen of the oscilloscope. The modulation should be between 81 and 99 percent.

c. The other audio-frequency amplitudes may be checked by grounding pins J201 or J204 as follows:

475-cycle, pin B on J204
650-cycle, pin C on J201
755-cycle, pin C on J204
955-cycle, pin D on J201
1390-cycle, pin E on J201
1900-cycle, pin E on J204
3000-cycle, pin F on J201

d. The amplitude of the 60 percent modulation may be checked by putting the percent modulation switch on "60%" and repeating steps b and c above. The modulation should be between 54 and 66 percent.

6—7. If the amplitude for one audio frequency is below minimum, replace the oscillator tube. If that does not

correct the fault, check the stage voltages and resistances, as shown in Figure 7–2. The amplitude of each audio oscillation is individually set by the 50K pot in the plate circuit, but these are set at the factory, and should not be moved until other components have been checked. The 50K potentiometer for the eight oscillators are marked R-257 to R-264, respectively. (See Figure 7–3.) They are on the side of the audio chassis, and are marked with the frequency of the individual oscillator.

6–8. If the amplitude for all audio frequencies is below minimum, check the voltage and resistance readings for the audio amplifier (V-214) and the modulator stage (V-217 and V-218) in Figure 7–2.

6–9. SYSTEM ANALYSIS. This analysis of the principal parts of Radio Transmitter Set AN/URW-3A is intended to locate a faulty component. This analysis makes use of test points which are shown in schematic diagrams and on photographs.

6–10. RADIO SET CONTROL C-711/URW-3. (See Figure 7–3.) Steps 1 through 14 should be made with the power off, or with control unit isolated.

TABLE VIII

TROUBLE ANALYSIS CHART

Step	Test Point	Test Equipment	Control Settings	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
1	B1 terminal G of J103	Ohmmeter connected from test point to terminal D of J103	Control stick in neutral. "CARRIER" switch on. "STUDENT-INSTRUCTOR" switch in "INSTRUCTOR" position	Zero	Proceed to step 2	Check for bad contact in switches S101, S102, S103, S104, S105, S106. Check wiring.
2	same	same	same except depress "PARACHUTE" switch	infinity	Proceed to step 3	Trouble is in switch S105, or in wiring.
3	same	same	same as step 1, except control stick to "RIGHT"	infinity	Proceed to step 4	Trouble is in switch S101, or in wiring.
4	same	same	same as step 1, except control stick to "LEFT"	infinity	Proceed to step 5	Trouble is in switch S102, or in wiring.
5	B1 terminal G of J103	Ohmmeter connected from test pbint to terminal D of J103	same as step 1, except control stick on "UP"	infinity	Proceed to step 6	Trouble is in switch S103, or in wiring.
6	same	same	same as step 1, except control stick on "DOWN"	infinity	Proceed to step 7	Trouble is in switch S104, or in wiring.
7	same	Ohmmeter connected from test point to terminal A of J103	same as step 1, except control stick to "RIGHT"	Zero	Proceed to step 8	Trouble is in switch S101, or wiring.
8	same	Ohmmeter connected from test point to terminal C of J103	same as step 1, except control stick to "LEFT"	Zero	Proceed to step 9	Trouble is in switch S102, or in wiring.
9	same	Ohmmeter connected from test point to terminal E of J103	same as step 1, except control stick to "UP"	Zero	Proceed to step 10	Trouble is in switch S103, or in wiring.

TABLE VIII (Cont.)

TROUBLE ANALYSIS CHART

Step	Test Point	Test Equipment	Control Settings	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
10	B1 terminal G of J103	Ohmmeter connected from test point to terminal F of J103	same as step 1, except control stick to "DOWN"	Zero	Proceed to step 11	Trouble is in switch S103, or in wiring.
11	same	Ohmmeter connected from test point to terminal J of J103	same as step 1	Zero	Proceed to step 12	Trouble is in "CARRIER" switch, or in wiring.
12	same	Ohmmeter connected from test point to terminal G of J102	"STUDENT INSTRUCTOR" switch on "STUDENT"	Zero	Proceed to step 13	Trouble is in "STUDENT-INSTRUCTOR" switch, or in wiring.
13	B2 terminal H of J103	Ohmmeter connected from test point to terminal H of J102	same as step 12	Zero	Proceed to step 14	Trouble is in "STUDENT-INSTRUCTOR" switch, or in wiring.
14	Same as step 13	Ohmmeter connected from test point to center conductor of phone jack J101	"STUDENT-INSTRUCTOR" switch on "INSTRUCTOR"	low — varies with volume control	Proceed to step 15	Trouble is in Volume control or wiring.

6–11. Dynamotor Unit PE-186C. (See Figure 4–10.) Radio Transmitting Set AN/URW-3A will be set up ready for operation when steps 15 through 19 are made.

15	1 terminal G of J502	D-C voltmeter, 0-500 volts range connected from test point to terminal H of J502	"FIL-OFF" switch on "FIL". "CARRIER" switch closed. "CONTROLLED CARRIER — CONTINUOUS" switch on "CONTINUOUS CARRIER".	400 volts. Red light on control unit lights, dynamotor runs.	Proceed to step 20	If dynamotor does not turn over, and light does not come on, proceed to step 16. If dynamotor turns over, but no voltage is shown, proceed to step 18.
16	A1 terminal A of J502	D-C voltmeter, 0-50 volts range connected from test point to ground	No change	28 volts	Proceed to step 17	Check voltage at input terminal A of J501. Check fuse F501. Check wiring between terminal A of J501 and terminal A of J502.
17	A2 Relay K502	None	No change	Relay closed, dynamotor rotates	Proceed to step 18	If relay does not close, check contacts of "CARRIER" switch, check contacts of "FIL-OFF" switch. Check relay K502 coil. If relay closes, but dynamotor does not rotate, check wiring; check brushes; check for open filter FL-502.

TABLE VIII (Cont.)

TROUBLE ANALYSIS CHART

Step	Test Point	Test Equipment	Control Settings	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
18	A3 Fuse F502	D-C voltmeter, 0-500 volts range, connected from test point to terminal H of J502	No change	400 volts	Proceed to step 19	Check brushes, brush connections, and wiring to fuse F502 from dynamotor.
19	A4 Relay K501	D-C voltmeter, 0-500 volts range connected from test point to terminal H of J502	No change	Relay closed	Check relay K501 contacts; check wiring between relay contacts and terminal A of J502	If relay does not close, check contacts of "CONTROLLED CARRIER" switch. Check coil of relay K501.

6–12. RADIO TRANSMITTER TS-421/URW-3 RADIO-FREQUENCY CIRCUITS ANALYSIS. (See Figure 4–9.) For this analysis the dynamotor unit will be connected to the transmitter, but Radio Set Control C-711/URW-3 will be disconnected.

20	E1 Meter M-201 on "DOUBLER GRID"	None required	"FIL-OFF" switch on "FIL". "TEST" switch held closed.	Meter reading about 27 ma.	Proceed to step 21	Trouble is in tube V-301 or components. Check tube, tube voltages and resistances, as shown in Figure 7–2.
21	E2 Meter M201 on "TRIPLER GRID"	None required	Same as step 20	Meter reading about 22 ma.	Proceed to step 22	Trouble is in tube V-301 or components. Check tube, tube voltages, and resistances, as shown in Figure 7–2.
22	E3 Meter M201 on "FINAL GRID"	None required	Same as step 20	Meter reading about 58 ma.	Proceed to step 23	Trouble is in tube V-302, or V-301 or components. Check tube, tube voltages and resistances, as shown in Figure 7–2.
23	2 Meter M201 on "FINAL PLATE"	None required	Same as step 20	Meter reading about 120 ma.	Radio-frequency circuits are all right. Proceed to audio-frequency circuits analysis	Trouble is in tube V-303, V-302, or V-301, or components. Check tube voltages and resistances, as shown in Figure 7–2.
24	G1 Connection between grid of V-301A and crystal to ground. Figure 4–3	Hewlett-Packard 410B VTVM or Equivalent	Same as step 20	Volts rms.	Oscillator input circuit is all right.	Trouble is in tube V-301 or components. Check tube voltages and resistances as shown in Figure 7–2.

TABLE VIII (Cont.)

TROUBLE ANALYSIS CHART

Step	Test Point	Test Equipment	Control Settings	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
6—13. RADIO TRANSMITTER TS-421/URW-3 AUDIO-FREQUENCY CIRCUITS ANALYSIS. (See Figure 7—3.)						
25 Part I	3 terminal H of J201 to ground	Voltmeter connected from test point to ground	Same as step 20, and pin A of J201 is grounded	10.9 volts rms.	Proceed to part 2 of step 25	Trouble is in audio-frequency circuits. Proceed to part 2 of step 25.
25 Part II		Oscilloscope; test point connected to vertical input of scope	Same as Part I	Sine wave 955 CPS	Audio-frequency circuits are all right	Trouble is in audio-frequency circuits. Proceed with Step 26.
26	E4 Meter M-201 on "MOD PLATE" (Figure 4—9)	None required	Same as Step 25	Meter reading 85 ma. (half of actual current)	Trouble is in output from modulator stage or modulation transformer. Check components.	Proceed with Step 27.
27	G4 Pin 7 of tube V-210 (Figure 4—6)	Oscilloscope, test points connected to vertical input of scope	Same as step 25	Sine wave 955 CPS	Proceed to step 28	Trouble is in oscillator components. Check tube, tube voltages and resistances as shown in Figure 7—2. Check oscillator coil.
28	G3 Pin 7 of tube V-214 (Figure 4—6)	Same as step 27	Same as step 25	Sine wave 955 CPS	Proceed to step 29	Trouble is in Tube V-210 or tube components. Check tube, tube voltages and resistances as shown in Figure 7—2.
29	G2 Pin 5 of tube V-217 or V-218 (Figure 4—7)	Same as step 27	Same as step 25	Sine wave 955 CPS	Audio oscillator and amplifier stages are all right.	Trouble is in tube V-210 or V-214 or components. Check tubes, tube voltages and resistances as shown in Figure 7—2.

6—14. TUNING RADIO-FREQUENCY CIRCUITS. (See Figures 1—3, 1—4, and 6—1.) Whenever the frequency is changed, and usually when the r-f tubes are replaced, it is necessary to retune the radio-frequency stages. It may also be found that, in time, component characteristics may change so that the panel meter no longer reads within the "LOAD" range at the time of the tuning and loading procedure as given in paragraph 6—15, therefore retuning will be required. To tune the radio frequency circuits proceed as follows:

CAUTION

The initial tuning of the r-f circuits should be done in "LOW POWER", to avoid heavy current flow through tubes from a mismatch.

Before starting push the "LOW POWER NORMAL" switch to "LOW POWER". The switch may be held by inserting a wire through the holes in the side of the switch.

a. Make certain that the proper crystal for the desired carrier frequency is in place. Connect the antenna.

b. Step 1: If the carrier frequency is to be changed from the frequency within the 50 to 70 megacycle range to one of the 70 to 95 megacycle range, or vice versa, make certain that switches S-301, S-302, S-303, and S-207 are in their proper positions. The tuning capacitors on the side of the chassis are marked with approximate frequency. Turn each capacitor to the frequency of the crystal. The 50 to 70 megacycle band for each switch and capacitor is marked with a black stripe, while the

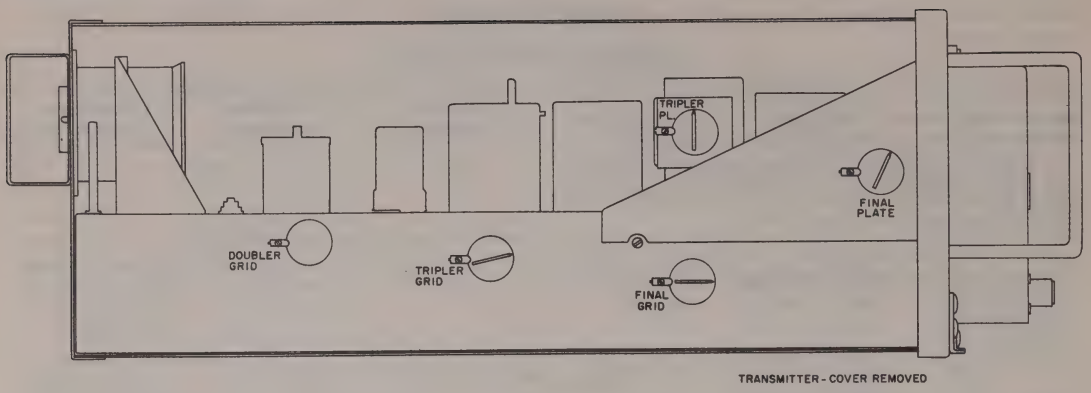


Figure 6–1. Screwdriver Adjustments of Doubler Grid, Tripler Grid, Final Grid, Tripler Plate, and Final Plate

70 to 95 megacycle band is marked with a red stripe. For the 50 to 70 megacycle band, the sliding switches (S-301, S-302, and S-303) are open and movable link S-207 is in the black position; for the 70 to 95 megacycle band, S-301, S-302, and S-303 are closed, and S-207 is in the red position.

c. Step 2: Turn the load coil adjustment ("LOAD") to the fully counter-clockwise position.

d. Step 3: Turn the "FIL-OFF" switch to the "FIL" position and allow 30 seconds for the filaments to heat.

e. Step 4: Turn the meter circuit selector knob on the front panel to "DOUB. GRID".

f. Step 5: Push and hold the toggle switch labeled "TEST" on the front panel of the transmitter, to the "TEST" position.

g. Step 6: Tune the "DOUB. GRID" capacitor, by means of a screwdriver, through the hole in the chassis at the far end of the transmitter until the maximum reading is indicated on the milliammeter.

h. Step 7: Release the "TEST" switch.

i. Steps 8 and 9: Turn the meter circuit selector knob to "TRIP GRID", then push and hold the "TEST" switch. Insert the screwdriver through the second hole marked "TRIP GRID", and adjust for the maximum milliammeter reading.

j. Step 10: Release the "TEST" switch.

k. Steps 11 and 12: Turn the meter switch to "FINAL GRID", then push and hold the "TEST" switch. Insert the screwdriver in the "TRIP PLATE", and adjust for maximum reading of the milliammeter.

l. Step 13: Insert the screwdriver in "FINAL GRID" and adjust for maximum reading of the milliammeter.

m. Step 14: Release the "TEST" switch.

n. Steps 15 and 16: Turn motor switch to "FINAL PLATE", then push and hold the "TEST" switch. Insert the screwdriver in the "FINAL PLATE" and adjust for a minimum or "resonance" on the milliammeter.

o. Step 17: Release the "TEST" switch.

p. Step 18: Place "HIGH-LOW POWER" switch in the "HIGH POWER" position.

q. Steps 19 and 20: Push and hold the "TEST" switch. Insert screwdriver in "FINAL PLATE" and again tune for minimum reading.

CAUTION

The preceding step should be done without delay since in the high power position the high current flowing through the final plate for any length of time may damage the tube.

r. Step 21: Release the "TEST" switch.

6–15. TUNING ANTENNA CIRCUIT AND LOADING TRANSMITTER. (See Figures 1–3 and 1–4.) It will be necessary to tune the antenna circuit and properly load the transmitter upon the completion of the tuning and adjusting of the transmitter described in the preceding paragraphs. To tune the transmitter and antenna circuit proceed as follows:

a. Steps 1 and 2: Ground the transmitter and connect the antenna as in actual operation.

Note

If the installation is on the ground, it will be necessary to install a ground plane before successful tuning and loading can be accomplished.

b. Step 3: Turn the "FIL.-OFF" switch on the front panel of Radio Transmitter TS421/URW-3 to the "FIL" position.

c. Steps 4 and 5: After 30 seconds, push and hold the "TEST" switch and turn the arrow switch to "LOAD LEVEL". The meter indicates the point which the meter should reach when the "LOAD" adjustment is turned.

With a 28-volt input, this should be within the darkened area of the meter.

d. Step 6: Insert a small screwdriver through the transmitter panel opening marked "LOAD", and turn the screw adjustment clockwise until the milliammeter reading increases approximately 20 milliamperes.

e. Step 7: Insert the screwdriver through the transmitter panel opening marked "TUNE", and adjust for maximum reading on the milliammeter.

f. Step 8: Turn the meter switch to the "LOAD LEVEL" position. Observe meter reading.

g. Step 9: Return the meter switch to the "FINAL PLATE" position.

h. Step 10: Insert the screwdriver in the panel opening marked "LOAD", and turn clockwise until the meter reading is the same as that observed in "f. Step 8" above.

i. Step 11: Insert the screwdriver in "FINAL PLATE", and again adjust for minimum reading on the milliammeter. If this reading is lower than that observed in "f. Step 8", repeat "h. Step 10".

j. Step 12: Release the "TEST" switch.

SECTION VII
MAINTENANCE

7—1. If Radio Transmitter Set AN/URW-3A fails to operate properly, very little repair work can be done in the aircraft or at the ground installation. However, it is possible to replace fuses, crystals, or tubes, check cables and connections, etc. This section lists some common troubles and remedies.

7—2. GENERAL SYSTEM TROUBLE-SHOOTING.

TABLE IX

TROUBLE-SHOOTING

Trouble	Probable Cause	Remedy
Dynamotor not turning.	No primary power supplied.	Check voltage of terminal A of J501. Restore primary power.
	Low-voltage fuse blown.	Replace fuse F-501.
	Relay K-502 coil burned out.	Replace relay K-502.
Dynamotor turning, but filaments don't light.	One or more tubes burned out.	Replace tubes.
	Plug J-202 or J-502 has a bad connection.	Repair or replace bad connection.
	"FIL-OFF" switch not making proper contact.	Clean or replace "FIL-OFF" switch.
One servo function missing.	One of tubes V-210 through V-213 is defective.	Replace defective tube.
	Cable from Radio Set control C-711/URW-3 to transmitter loose or defective	Repair or replace cable or connections as necessary.
	One switch in the control set is defective.	Replace defective switch.
All five servo functions missing, but dynamotor rotates.	Defective tubes V-210 through V-213.	Check and replace defective tubes.
	Tubes V-214, V-217, V-218, or V-301 through V-303 defective.	Check and replace defective tubes.
	No high voltage present.	Check high-voltage relay K-501 in dynamotor unit. Repair or replace.
	Fuse F-502 burned out.	Replace F-502.
	Dynamotor not putting out high-voltage power.	Check dynamotor high-voltage winding and brushes. Replace as necessary.
	Contact G on plug J-502 (test point 1) or J-202 broken or otherwise defective.	Replace or repair J-502 or J-202.

TABLE IX (Cont.)

TROUBLE-SHOOTING

Trouble	Probable Cause	Remedy
All five servo functions missing, but dynamotor rotates. (Cont.)	Incorrect crystal installed in Radio Transmitter TS-421/URW-3.	Replace crystal with correct crystal.
	Defective crystal.	Replace crystal.
	Receiver frequency differs from transmitter frequency.	Check and correct receiver frequency.
	Antenna switch S-207 is not closed.	Close switch S-207.
	Antenna or antenna cable defective.	Replace or repair antenna or antenna cable.
	Transmitter not properly tuned and antenna not loaded correctly.	Tune transmitter and load antenna.
	No ground plane for antenna when equipment is ground installation.	Install ground plane.
No indication on meter in any position of meter switch, but dynamotor rotates.	Defective high-voltage fuse.	Replace fuse F-502.
	Loose or defective plugs on cables.	Tighten or repair plugs on cables.
	Dynamotor is not putting out high-voltage power.	Check brushes and relay K-501. Replace or repair as necessary.
No indication on meter at "DOUBLER GRID", "TRIPLER GRID", "FINAL GRID", or "FINAL PLATE".	Tube V-301 defective.	Replace tube V-301.
	Improper crystal being used.	Replace with proper crystal.
No indication on meter at "TRIPLER GRID", "FINAL GRID", or "FINAL PLATE".	Tube V-301 defective.	Replace tube V-301.
No indication on meter at "FINAL GRID" or "FINAL PLATE".	Tube V-302 defective.	Replace tube V-302.
No indication on meter at "FINAL PLATE".	Tube V-303 defective.	Replace tube V-303.
No indication on meter at "MOD PLATE".	Tubes V-217 and V-218 defective.	Replace tubes V-217 and V-218.
Meter reads outside "LOAD" range at "FINAL PLATE" position on meter switch.	Plug on cable from antenna to transmitter loose or defective.	Tighten or repair plug or cable between antenna and transmitter.
	Poor or broken cable between antenna and transmitter.	Check continuity with ohmmeter, repair or replace cable as required.
	Transmitter improperly tuned or not properly loaded.	Retune antenna circuit and reload transmitter.
	Transmitter is not loaded due to lack of a ground plane when the equipment is being used on the ground.	Install a ground plane.

7–3. NEITHER CARRIER NOR AUDIO TONES PRESENT. Check fuses F-501 (40 amperes) and F-502 (0.6 ampere) located on top of the base of the dynamotor unit. Replace them with the spares provided. If dynamotor unit PE-186C does not run but the tube heaters light, check the low-voltage relay K-502 to see if the armature is actuated when the "CARRIER" switch on Radio Set Control C-711/URW-3 is closed. If it is not actuated check test coil, cable, and switch for continuity, using VTVM Hickok 110A or 110B, or equivalent. If the relay coil is open replace the relay.

7–4. Using LS-189 voltmeter or equivalent, check high voltage filters FL-501 and FL-503 for continuity. If they are open, replace the filters.

7–5. If the dynamotor runs, but the heaters do not light, test all tubes for heater continuity with VTVM Hickok 110A or 110B or equivalent. The heaters generally are series-connected in pairs so that two tubes will fail to light at one time. Test the audio frequency tubes in a tube tester. The best check for JAN-815 tubes is performance, as indicated by the panel meter.

Replace any doubtful JAN-815 tubes with ones known to be good. If V-217 and V-218 are replaced and the transmitter does not operate satisfactorily, it will be necessary to make further checks as given in paragraph 7–8.

Note

Consume all tubes of a given type supplied with equipment before employment of tubes from general stock.

7–6. Test the battery cable for continuity, and also test the primary supply voltage with VTVM Hickok 110A or 110B or equivalent. Connections at the primary must be of the correct polarity for operation. Check the dynamotor output. The output should be approximately 400 mills at 400 volts.

7–7. Test tube d-c voltages with a 20,000 ohm-per-volt meter (Voltmeter IS-189 or equivalent). Refer to figure 7–2, listing the voltages of the tubes of this unit. If a voltage reading varies more than a plus or minus 15 percent from that shown, the circuit constant at fault must be determined by test, using the schematic diagram (figure 7–1) as a guide.

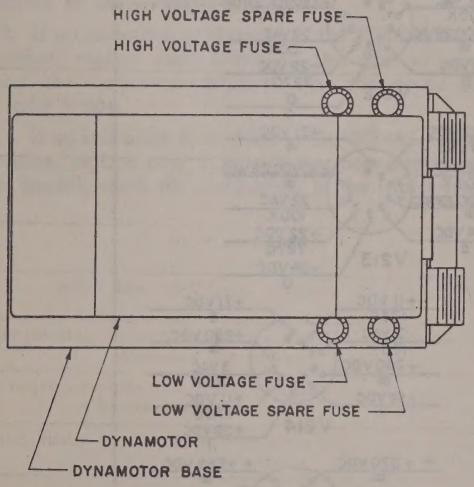


Figure 7–1. Location of Fuses on Dynamotor Unit PE-186C

7–8. CARRIER PRESENT BUT MODULATION NOT EFFECTIVE. Check for presence of audio tones by following the directions in paragraph 6–3. If the 3000-cycle tone is not heard, check tube V-213 in a tube tester. If the 1390-cycle tone is not heard, check V-211 in the tube tester. For the 955-cycle tone check the tube V-210, for the 650-cycle tone, check V212, for the 300-cycle tone, check V-210. Note that the 475, 755, and 1900-cycle audio oscillators are not used in this equipment with Radio Set Control C-711/URW-3. If the tubes check satisfactorily, check oscillator coils T-203 through 210 for open or grounded windings by means of VTVM Hickok 110A or 110B or equivalent. If any of these windings are faulty, the tuned-choke assembly must be replaced. If the trouble still has not been located, test with Voltmeter IS-189 or equivalent for the correct tube socket voltages. Refer to the voltage diagram in figure 7–2. If these voltages vary appreciably (more than plus or minus 15 percent of the given values), the circuit component at fault must be determined by test, using the schematic diagram as a guide.

7–9. If the tones check satisfactorily, perform the following checks:

a. Remove tubes V-214, V-215, V-217, and V-218 (the audio amplifier and driver tubes). Test them in the tube tester. Replace them with spares if weak or inoperative.

b. With LS-189 voltmeter, or 110B, or equivalent, test switch S-206 for a good electrical contact. If the contact is intermittent, or not positive, replace the switch. Make certain that the switch is in the "90%" position.

c. With the meter, test the windings of each half of the modulator-transformer T-202 and the driver transformer T-201 for open circuits or grounds. If the windings are faulty, replace the transformer.

d. Check voltages at the tube sockets V-210 through V-213 with the voltmeter IS-189 or equivalent for the correct tube socket voltages as given in figure 7–2. If these voltages vary appreciably (more than plus or minus 15 percent of the given values) the circuit constant at fault must be determined by test, using the schematic diagram as a guide.

e. Replace modulator tubes V-217 and V-218 with spares known to be good, and compare with previous performance. Check the plate circuit by turning the selector switch to "MOD. PLATE". The reading should be about 66 milliamperes (half of actual current) with no modulation.

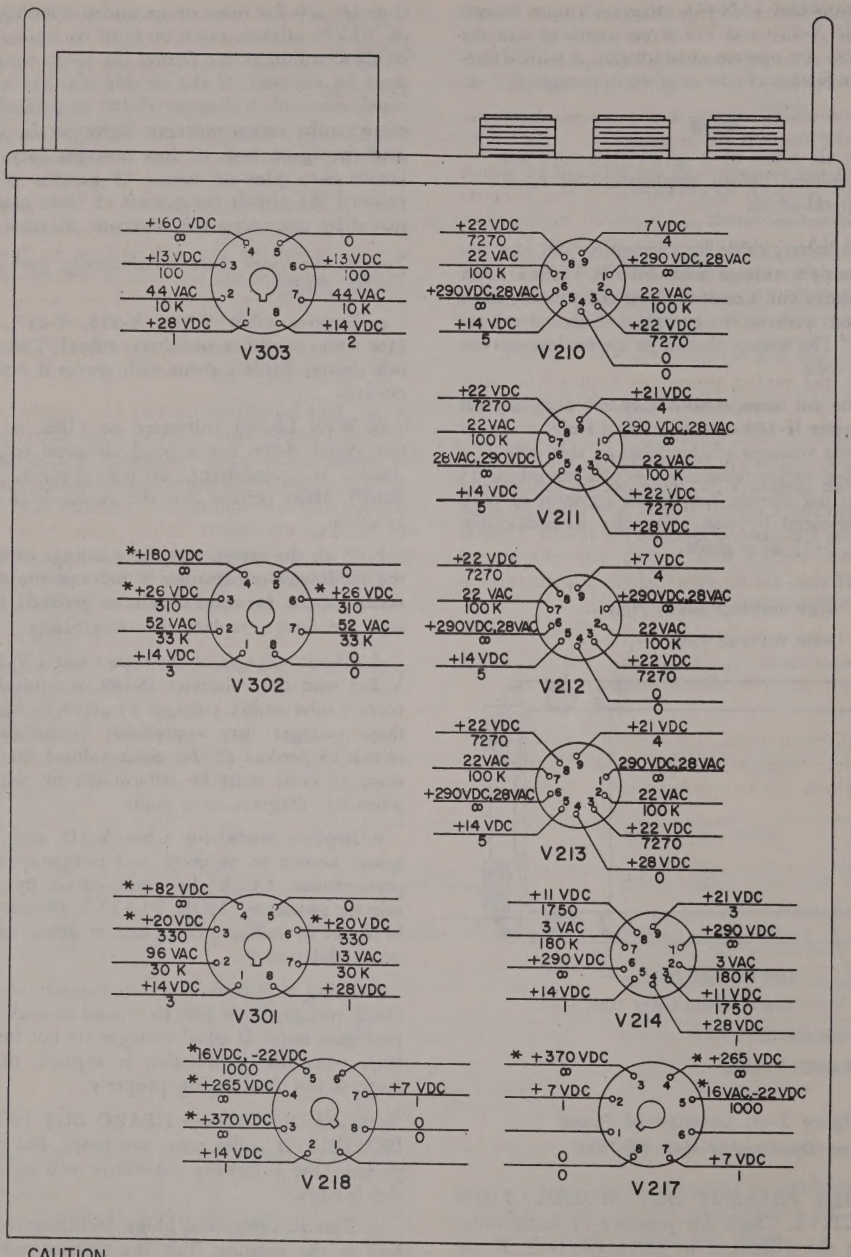
f. Using a Hickok No. 110 vacuum-tube voltmeter, check voltages from grid to ground on each half of each push-pull stage. If equal voltages are not found on each half, when the modulation is applied, the preceding stage is not functioning properly.

7–10. AUDIO TONES HEARD BUT NO CARRIER PRESENT. If audio tones are heard, but no carrier is present, the following procedure will aid in locating the trouble.

a. Test all cables and plugs, including the r-f coaxial line to the antenna. Test the antenna cable both for shorts and an open circuit. Repair or replace the cables if necessary.

b. Replace the r-f tubes (V-302, V-301, V-303) if in doubt as to operation.

c. Test tube-socket voltages for these tubes with a 20,000 ohm-per-volt-meter (Voltmeter IS-189 or equivalent). If they do not closely approximate those indi-



CAUTION

READINGS MARKED BY ASTERISK ARE MEASURED FROM THE 28-VOLT BUS. IF THE MEASURING INSTRUMENT HAS A COMMON A-C & D-C GROUND, BE SURE THE CHASSIS GROUND IS REMOVED BEFORE MEASURING DC VOLTAGE

Figure 7—2. Bottom View of Radio Transmitter TS-421/URW showing Tube Sockets with Voltage and Resistance Chart

cated in the tube-socket voltage diagram (figure 7—2), test the circuit elements in the stage where any appreciable difference is found. Replace all components which are found defective.

d. Test the contacts of plug P-201 for good connections. Clean the contacts, if necessary.

e. Test both the contacts and the position of switch S-201 ("LOW POWER-NORMAL"). If the contacts are bad, replace the switch. This switch must return to the "NORMAL" position when released.

f. Check the r-f chokes with an ohmmeter (the Hickok 110A vacuum-tube voltmeter) for continuity. The chokes are constructed with wire that may easily be cut or broken.

7—11. Follow the tuning procedure outlined in paragraph 6—14, at the same time noting the first stage at which no output is indicated by the meter.

a. If no meter indication is observed in the "DOUB. GRID" position crystal Y-201 may not be functioning properly. Substitute a crystal that is known to be good and of the same frequency. Compare the results. If there is no difference, replace tube V-301, with one known to be good. If this has no effect, check the other components of the oscillator stage.

b. If no indication is obtained in the "TRIP. GRID" position, replace tube V-301. If this has no effect, check the component associated with the second half of tube V-301.

c. If no indication is obtained in the "FINAL GRID" position, replace tube V-302. If this does not correct the trouble, check the components in the tripler stage.

d. If no indication is noted in the "FINAL PLATE" position, replace tube V-303. If no improvement is noted, check the circuit components in the final amplifier stage.

7—12. REPLACEMENT OF FUSES. One high-voltage fuse (0.6 amperes) and one low-voltage fuse (40 amperes) are located on the top of the base of Dynamotor Unit PE-186C. Next to each fuse is the spare of the correct value available for replacement purposes. To check a fuse, loosen the cap and remove the fuse cartridge. Observe whether the cartridge is burned out; if so, replace the spare next to it of the same value. If the spare then burns out, check for shorts before replacing the fuse. Place a new fuse in spare holder, before placing the equipment in operation.

7—13. REPLACING CRYSTAL. Radio Transmitter TS-421/URW-3 uses Crystal Unit CR-1A/AR, coded to indicate the exact frequency. Make sure that the coding of the replacement crystal corresponds with the desired carrier frequency. No polarity need be observed in placing the crystal holder prongs into the socket. Under no circumstances should crystal elements be removed from their holders or otherwise tampered with, except by fully experienced and qualified personnel.

7—14. REPLACING TUNING UNITS. To replace a defective tuning unit with a new one, first separate the tuning unit from the main chassis by disconnecting the leads from terminal board TB301, and removing the machine screws along the side and on the top of the chassis. Remove the old tuning unit. Place the new tuning unit in position, and replace the leads and screws.